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IN THIS ISSUE

Reliability of Taste Testing and Consumer Testing Methods. I. Fatigue in Taste Testing / *387*

Reliability of Taste Testing and Consumer Testing Methods. ii. Code Bias in Consumer Testing / *389*

Variation in Determinations of Shear Force by Means of the "Bratzler-Warner Shear / *391*

Temperature of Popper in Relation to Volumetric Expansion of Popcorn / *394*

Microwave Irradiation of Orange Juice Concentrate for Enzyme Inactivation / *397*

The Fluorescence of Liquid Egg. I. The Relation Between the Fluorescence and the Mustiness of Frozen Whole Egg / *400*

The Fluorescence of Liquid Egg. II. The Effect of Specific Bacteria / *406*

Some Factors Affecting the Sodium Chloride Content of Haddock During Brine Freezing and Water Thawing / *409*

Varietal Differences in Cucumbers for Pickling / *415*

Factors Influencing the Quality and Texture of Frozen Cultivated Blueberries / *418*

Detection of Washed Eggs by Conductivity Measurements. II. Field Testing / *422*

Metal Cans of the Future / *424*

Affairs of the Institute / *2*

The season for SUCARYL (Cyclamate, Abbott) is 12 months long!

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Affairs of the Institute

Proceedings of the Council
Plans for the Columbus Meetings Under Way
News of the Regional Sections
Masters and Doctors in Food Technology
Selected Abstracts
Recently Elected Members of IFT
Books
Food Industry Topics
Future Meetings

Proceedings of the Meeting of the Council

The Biltmore Hotel
Los Angeles, California
June 27, 1954

The meeting was called to order at 10:00 A.M. by President Clark.

Present

B. S. Clark, Pres.
P. K. Bates, Pres. Elect No. 1
B. E. Proctor, Past Pres.
A. G. Olsen, Treas.
A. N. Prater, Asst. Treas.
L. E. Clifcorn, Pres. Elect No. 2
H. C. Diehl, At Large
G. F. Garnatz, At Large
W. A. MacLinn, At Large
C. O. Ball, At Large
C. A. Greenleaf, At Large (Alt.)
K. G. Dykstra, At Large
F. W. Fabian, At Large
M. A. Joslyn, At Large
G. E. Brissey, Chicago
J. M. Jackson, Chicago
R. F. Cohee, Chicago
D. A. Huber, Chicago
H. T. Griswold, No. Cal.
E. E. Jacobs, No. Cal.
A. C. Richardson, No. Cal.
M. E. Highlands, N. E.
L. B. Sjostrom, N. E.
J. A. Dunn, N. E.
M. E. Powell, So. Cal.
W. E. Baier, So. Cal.
J. N. Dempsey, St. Louis, Alt.
C. N. Frey, N. Y.
L. Atkin, N. Y.
P. X. Hoynak, N. Y.
P. G. Miller, N. Y. Alt.
F. C. Baselt, N. Y. Alt.
W. R. Roy, Fla.
P. Paul, Gr. Lakes, Alt.
E. C. Dryden, Phila., Alt.
A. H. Warth, Md.
E. G. Heyl, Md.
C. W. Hurlbut, Puget Sound
J. C. Ayres, Ames, Alt.
N. H. Volle, Ohio Valley
O. J. Worthington, Oregon, Alt.
J. G. Woodroof, Dixie, Alt.
A. Roche, Aust. No., Alt.
N. W. Desrosier, Ind.
F. E. Atkinson, Br. Columbia, Alt.
J. David, Aust. So., Alt.
R. E. Morse
H. S. Olcott
H. Lineweaver
B. Grossi
R. B. Wakefield
Z. I. Kertesz
S. C. Prescott
M. S. Peterson, Editor
C. S. Lawrence, Exec. Secy.

Greetings, Introductions, and Announcements

Dr. L. E. Clifcorn, President-Elect for 1955-56, was presented by President Clark and greeted by the Council.

Mr. John N. Dempsey, General Arrangements Chairman for the 1956 meeting at St. Louis, was introduced by Dr. Clifcorn.

Greetings were extended to Mr. Allen Roche and Mr. John David representing our two Australian Regional Sections.

President Clark announced the results of the 1954 election of Councilors-at-large to be: B. S. Clark, J. Avery Dunn, C. N. Frey, L. A. Hall, and H. S. Olcott.

Reports Presented and Approved

Milton Powell—Status of 14th Annual Meeting Arrangements.

A. N. Prater—Program for the 14th Annual Meeting.

J. S. Jenner—Objectives of the Civil Defense Administration and Cooperation of the Food Industries.

Charles S. Lawrence—Report of the Secretary (Appendix A).

Aksel G. Olsen—Report of the Treasurer (Appendix B).

Martin S. Peterson—Report of the Editor (Filed with the Secretary).

Mr. Ray Wakefield—Report of the Committee on Publications (Filed with the Secretary).

Finance Committee—Budget for 1954-55 (Appendix C).

(Other committee reports were made but not at the Council Meeting.)

Motions Made, Seconded, and Passed

The Journals

Page budget of Food Technology be 1080 pages *per annum* with the President authorized to increase or decrease the quota depending on journal income.

Page budget of Food Research be 618 pages *per annum*.

Cedric D. Atkins be confirmed as member of Editorial Board, Food Technology, to fill vacancy.

Subscription rates to Food Research be $7.50 per year for members, $8.50 for non-members (domestic), $10.00 for non-members (foreign).

Press overruns of the Journals be limited to 50 copies per issue except during first 3 months of the calendar year (to meet anticipated renewals).

Appointments

Reappointed to office for a term of one year: Martin S. Peterson, editor of the journals; Aksel G. Olsen, treasurer; Arthur N. Prater, assistant treasurer; Charles S. Lawrence, executive secretary; Marian A. Gilchrist, assistant executive secretary.

Annual Meetings

The invitation from the Philadelphia section for the 1959 Meeting be accepted.

The invitation from the Northern California section for the 1959 Meeting be resubmitted as an invitation for the 1960 meeting.

IFT Committees

The Awards Committee be authorized to change the rules governing the Babcock-Hart Award in order to establish September 1st as the opening and November 1 as the closing date for nominations and to authorize the President to appoint three new jurors each year.

The Ad Hoc Committee on Food Standards be discontinued, the president to appoint a committee to cooperate with the Food and Nutrition Board in setting up prehearing conferences on Definitions and Standards of Identity for Foods.

The Committee on Education be instructed to submit, prior to the next Annual Meeting, a report as to the minimum requirements for training in Food Technology.

Applications for membership (submitted by the *Qualifications Committee* for Council decisions) be decided as follows: Members: E. G. Poindexter, Gordon F. Watson; professional members: Adrian W. Kaufmann, Shirley I. Vollmer (change of status).

Institute representatives to the American Association for the Advancement of Science be appointed on a calendar year basis.

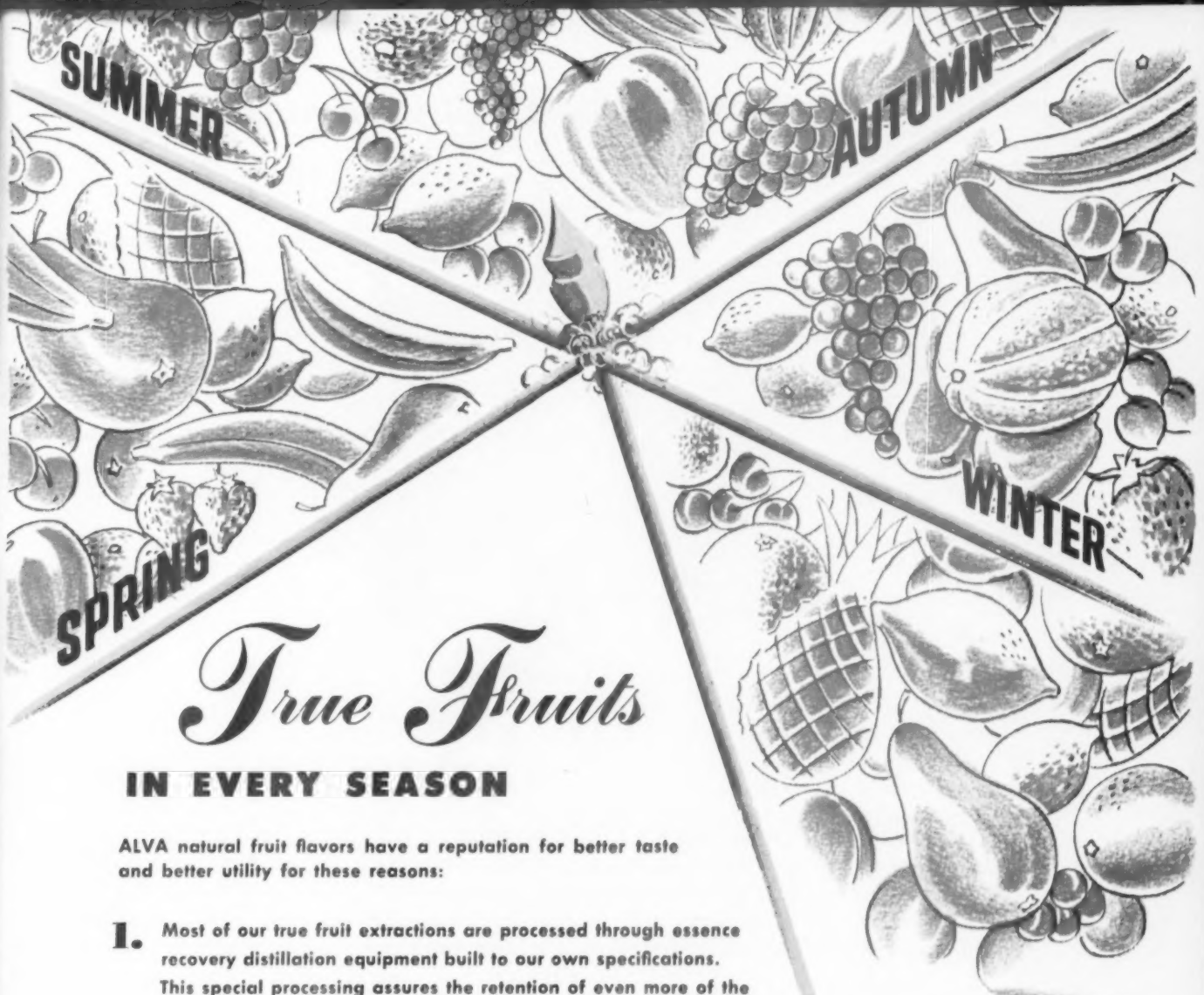
Commendations and Resolutions:

The unanimous appreciation of the Institute for the excellent work of President Clark in setting up the new relationship between the Institute, the National Research Council, and the Food and Drug Administration.

Special commendation for the work of the Publications Committee and the Awards Committee.

The thanks and appreciation of the Institute for a proposed award to be sponsored by the Australian Section and presented each year at the annual meeting of IFT. (This matter is in the preliminary stages of discussion and will be worked upon further by the Awards Committee, as recommended by representatives of the Australian Sections.)

The meeting was adjourned at 3:30 P.M.



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IN EVERY SEASON

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1. **Most of our true fruit extractions are processed through essence recovery distillation equipment built to our own specifications. This special processing assures the retention of even more of the light fugitive esters so difficult to hold in normal extraction procedures.**

2. **Storage facilities are maintained under ideal control conditions, improving the life of flavors and guaranteeing freshness in each delivery.**

3. **Through the years ALVA has developed procedures for handling fresh fruit which assure 100% purity.**

ALVA true fruit flavors are ideal for every use, and the ALVA laboratories are eager to help with recommendations and samples for every true fruit problem.

VAN AMERINGEN-HAEBLER, INC.

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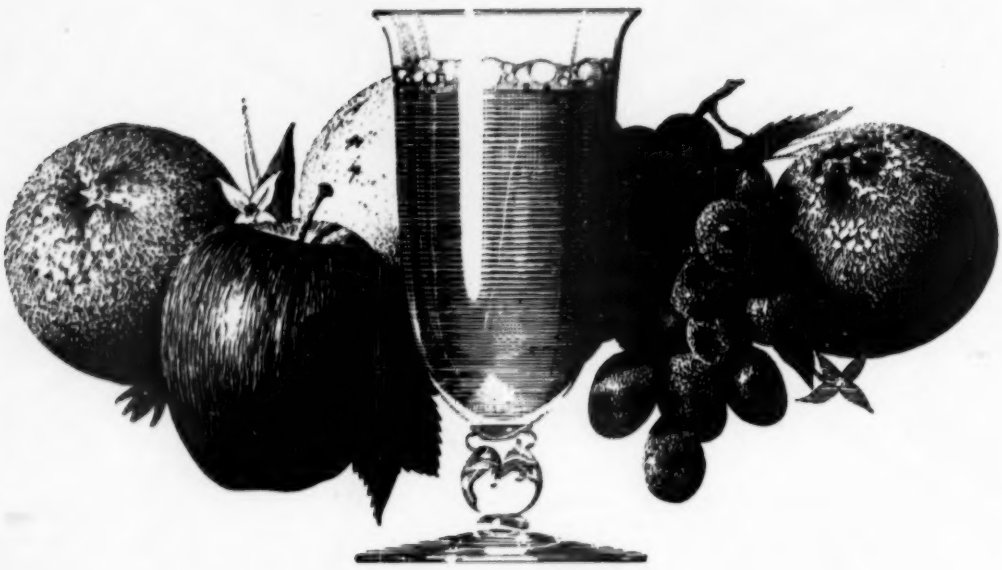
Your juice needs this advantage



Did you know that ascorbic acid may be added to certain fruit and vegetable juices to standardize their vitamin C content, thus overcoming wide variations which can occur *(see table below)*. Many nutritionists believe that the public interest is best served when the ascorbic acid content of processed juices is so standardized. The cost is nominal, the processing simple. A label statement of 100% of the minimum daily adult requirement for essential vitamin C may be made when a serving of juice contains 30 mg. of ascorbic acid.

Why send your juice to market with the "handicap" of inadequate nutritional value? Use Roche ascorbic acid to standardize its vitamin C content. We have helped many processors to make their good foods better and we're ready to help you. Why not investigate today?

Ascorbic Acid Content of Canned Juices

Below are examples of minimum and maximum levels of ascorbic acid in commercially canned juices. Note the wide variations! All figures are in milligrams per 100 grams of juice. Data from U. S. Department of Agriculture.

	Min.	Max.
Grapefruit juice	10.0	49.0
Orange juice	9.7	70.0
Pineapple juice	5.4	18.0
Apple juice	0.2	3.6
Grape juice	0.0	4.7
Tomato juice	2.5	32.0

It is in the public interest to standardize the vitamin C content of these processed juices and juice products.

Orange — Grapefruit — Lemon — Tangerine — Apple Grape — Pineapple — Cranberry — Tomato Vegetable blends

No matter which type of processing you use— Canning • Concentrating • Freezing • Dilution in the form of "ades"—your juice will be better when its ascorbic acid content is standardized.

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In Canada: Hoffmann-La Roche Ltd., Montreal, Que.

FOOD TECHNOLOGY

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11606 South Bell Avenue, Chicago 43

Address to this office all manuscripts, proofs, letters pertaining thereto, etc. Prospective contributors are invited to send for the pamphlet *Information and Suggestions to Authors* which contains style instructions.

Responsibility for statements appearing in FOOD TECHNOLOGY rests on the author thereof; points of view expressed in the columns of the journal do not necessarily have the indorsement of the Institute of Food Technologists. Mention of commercial products in the technical pages of this Journal is not to be construed as a recommendation of such products over others in the same category.

Business Manager
CHARLES S. LAWRENCE
176 West Adams St., Chicago 3, Illinois

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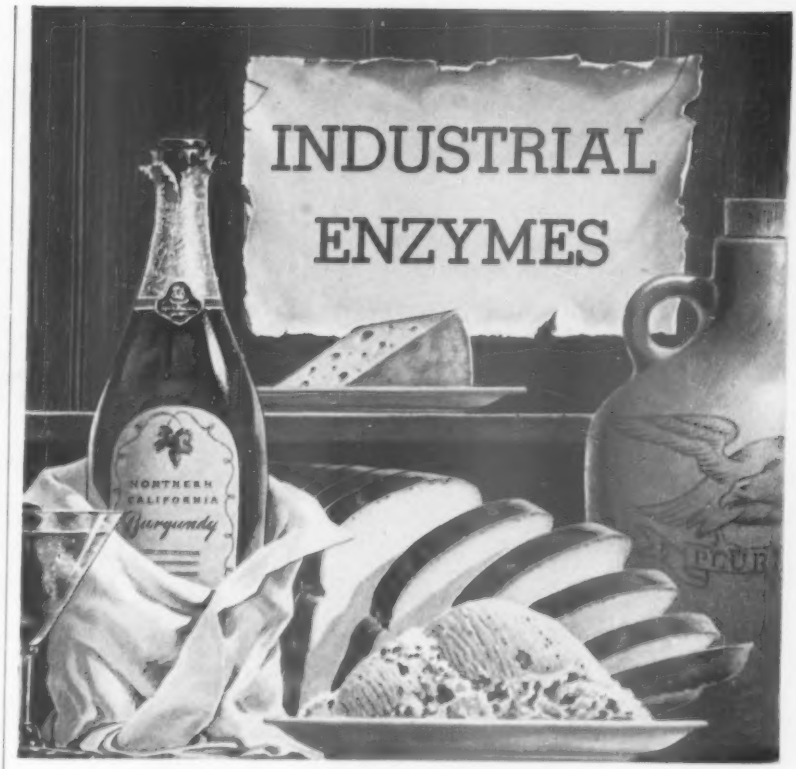

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In contrast to many chemicals, Rohm & Haas industrial enzymes are *natural* products, which catalyze *specific* reactions and prevent undesirable side-reactions. A little enzyme goes a long way toward increased process efficiency, toward big gains in sales appeal.

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APPENDICES

A. Secretary's Annual Report

TO THE COUNCIL:

1. MEMBERSHIP:

Total paid members, May 1, 1953		3,643
LOSSES: Deaths and resignations	76	
Dropped for non-payment	219	
Total losses		295
BALANCE		3,348
GAINS: Reinstatements and New Members elected		588
TOTAL PAID MEMBERS, APRIL 30, 1954		3,936
Net Gain for Fiscal Year '53-'54	293	
Net Gain for Fiscal Year '52-'53	257	
Net Gain for Fiscal Year '51-'52	178	

CLASSIFICATION OF MEMBERS:

	1952	*1953*	*1954*	*Net Gain or Loss*	
Professional Members	2,352	2,505	2,660	plus	155
Members	855	859	1,101	plus	143
Student Members	179	180	175	minus	5
TOTAL	3,386	3,643	3,936	plus	293

2. JOURNAL CIRCULATION:

FOOD TECHNOLOGY:			
Member Subscribers		3,936	
Non-Member Subscribers:			
U. S. and Territories	357		
Canada	53		
Other Foreign	332		
Total Non-Member		742	
TOTAL PAID CIRCULATION			4,678
Advertisers, agencies, representatives, complimentary and exchange			182
TOTAL CIRCULATION			4,860
Net Gain in paid circulation for the year			389
FOOD RESEARCH:			
Member Subscribers		689	
Non-Member Subscribers:			
U. S. and Territories	710		
Canada	50		
Other Foreign	494		
Total Non-Member		1,254	
TOTAL PAID CIRCULATION			1,943
Advertisers, agencies, complimentary and exchange			28
TOTAL CIRCULATION			1,971
Net Gain in paid circulation for the year			124

3. FINANCIAL STATEMENTS

The following paragraphs are taken from the:

AUDITOR'S REPORT
rendered by George V. Roundtree & Co.
Certified Public Accountants

Following is a summary of the financial condition of the Institute at April 30, 1954 and April 30, 1953:

Particulars	*April 30, 1954*	*April 30, 1953*	*Increase Decrease**
ASSETS			
Current assets:			
Cash	$47,329.25	$61,009.72	$13,680.47*
Accounts receivable	3,999.86	1,853.38	2,146.48
U. S. Treasury notes	19,948.00		19,948.00
Investment	887.00	861.00	26.00
Inventories	156.15	59.80	96.35
Prepaid insurance	217.05	241.16	24.11*
Furniture and fixtures (net)	601.84	755.67	153.83*
Total	$73,139.15	$64,780.73	$ 8,358.42
LIABILITIES AND CAPITAL			
Current liabilities		$ 100.00	$ 100.00*
Deferred income	$ 9,144.00	8,265.33	878.67
Capital	63,995.15	56,415.40	7,579.75
Total	$73,139.15	$64,780.73	$ 8,358.42

Cash:
General fund, $43,439.33;
Operating fund, $3,889.92

Accounts receivable:
The Garrard Press, $983.72;
The Best Foods, Inc., $3,016.14

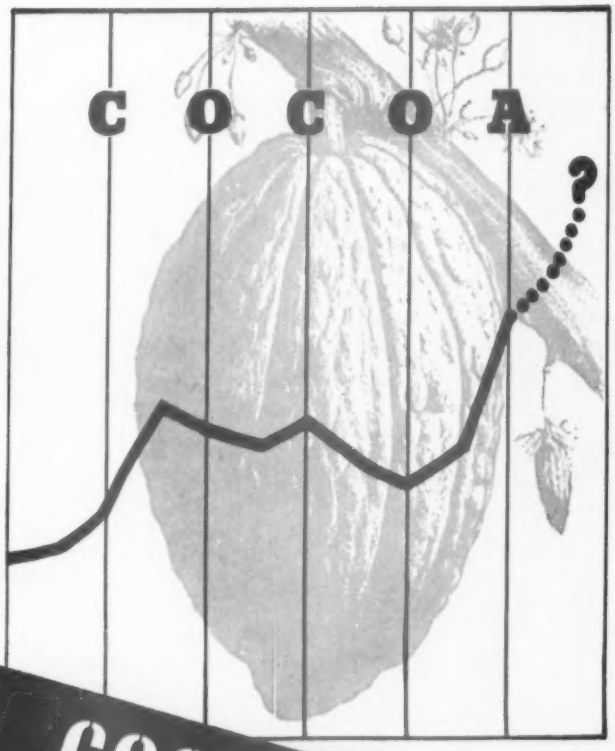
Bank balances are in agreement with a certificate furnished us by the First National Bank of Chicago after taking into consideration checks not presented for payment April 30, 1954.

The balance due from The Garrard Press represents principally charges for advertising in FOOD TECHNOLOGY and FOOD RESEARCH which the publisher collects from advertisers and remits to the Institute. The balance which was confirmed directly with the publisher may be summarized as follows:

FOOD TECHNOLOGY	$587.67
FOOD RESEARCH	396.05
Total	$983.72

The $3,016.14 due from The Best Foods, Inc. represents a charge for excess costs of special preprints and reprints relating to sorbic acid.

(Continued on page 8)



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FOLLOW THE RISING CURVE of cocoa bean prices and you become acutely aware of a situation that means vanishing profits for the makers of coatings, confections, fondants and many other chocolate type goods. Happily for them, however, new technical advances employed by our Flavor Research Laboratories in the production of our COCOA and CHOCOLATE INTENSIFIERS has resulted in a group of specialties capable of effecting savings of as much as 25% and more of the natural chocolate used. It will be well worth your while to sample these new chocolate fortifiers . . . *NOW!*

Write for samples and prices . . . on your letterhead, please. Specify type of product made and the pounds of chocolate ordinarily used for a properly flavored 100 lb. batch.

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BRANCH OFFICES *and* †STOCKS: *Atlanta, Georgia, Boston, Massachusetts, †Chicago, Illinois, Cincinnati, Ohio, Cleveland, Ohio, †Los Angeles, California, Philadelphia, Pennsylvania, San Francisco, California, St. Louis, Missouri, †Toronto, Canada and †Mexico, D. F.* FACTORY: *Clifton, N. J.*

(Continued from page 6)

U. S. Treasury 90-day notes, $19,948.00

The Institute owns $20,000.00 face value U. S. Treasury notes due July 22, 1954. These notes are held by the First National Bank of Chicago for safe-keeping.

Investment:
U. S. Savings Bond, Series "F", $887.00

The Series "F" bond, having a face value of $1,000.00, and a redemption value at April 30, 1954 of $887.00 was inspected in the vault of the First National Bank of Chicago.

Inventory, $156.15

The inventory consists of emblem seals and membership certificates held for sale to members.

Unexpired insurance, $217.05

In addition to a blanket position bond of $50,000.00, the Institute carries workmen's compensation and general liability insurance. Unexpired premiums at April 30 were computed at $217.05.

Furniture and fixtures, $601.84

Additions to furniture and fixtures amounted to $330.22 as detailed below:

4 shipping cases	$ 74.42
Electric fan	56.05
Contour chair	96.90
2 folding tables	61.10
Office chair	41.75
Total	$330.22

Depreciation was computed for the year at the rate of 20% per annum amounting to $484.05.

Deferred income, $9,144.00

Non-members' subscriptions to FOOD TECHNOLOGY and FOOD RESEARCH are billed on a calendar year basis. Since the Institute is required to furnish journals to subscribers for the remainder of the year, subscriptions for the eight months ending December 31, 1954 amounting to $9,144.00 have been deferred.

Capital, $63,995.15

The capital at May 1, 1953 amounted to $56,415.40 to which is added the current net income of $7,579.75 making a balance at close of the year of $63,995.15.

BALANCE SHEET

April 30, 1954

ASSETS

Current Assets			
Cash:			
General fund	$43,439.33		
Operating fund	3,889.92	$47,329.25	
Accounts receivable:			
The Garrard Press	983.72		
The Best Foods, Inc.	3,016.14	3,999.86	
U. S. Treasury 90-day notes—at cost		19,948.00	71,277.11
Investment			
U. S. Savings Bond Series F due August 1957—at redemption value			887.00
Inventory			
Emblem seals and membership certificates			156.15
Unexpired Insurance			217.05
Furniture and Fixtures			
At cost		2,420.27	
Less: Allowance for depreciation		1,818.43	601.84
Total			$73,139.15

LIABILITIES AND CAPITAL

Deferred Income			
Non-members subscriptions to journals			$ 9,144.00
Capital			
Balance May 1, 1953		$56,415.40	
Add: Net income year ended April 30, 1954		7,579.75	63,995.15
Total			73,139.15

(Continued on page 10)

try these amazing, stable

FELCOFIX*

powdered flavors

IDEAL LONG-LIFE FLAVORS FOR

- Baked Goods
- Confections
- Desserts
- Dough and Flour Mixes
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- Spice Mixes
- Tablets
- Vitamins
- Wafers

Felton's complete line of FELCOFIX powdered flavors offers you the best answer to the problem of permanently flavoring all kinds of dry, semi-dry or powdered products . . . completely eliminating that old shelf-life bugaboo!

These outstanding flavors are supplied as dry, perfectly homogeneous powders that remain fresh, true and delicious even when used in mixtures containing acids, sugars and other reactive ingredients.

Their concentration and lasting power are equally amazing, and result in economies that are important to your profits.

It will pay you to try our FELCOFIX flavors without delay!

Write now for Samples of these amazing new **FELCOFIX*** locked-in **FLAVORS**

FLAVORS • ESSENTIAL OILS • AROMATICS

FELTON CHEMICAL COMPANY, INC.
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*FELCOFIX is a trade mark of Felton Chemical Co., Inc.

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(Continued from page 8)

INCOME AND EXPENSE STATEMENT

Year Ended April 30, 1954

Particulars	*Together*	*Institute Operations*	*Food Technology*	*Food Research*
Income				
Membership dues	$ 28,665.70	$14,332.85	$14,332.85	
Non-membership subscriptions—FOOD TECHNOLOGY	6,157.91		6,157.91	
Subscriptions—FOOD RESEARCH	12,351.71			$12,351.71
Advertising—FOOD TECHNOLOGY	58,922.23		58,922.23	
Advertising—FOOD RESEARCH	645.00			645.00
Proceeds from annual meeting (net)	2,223.03	2,223.03		
Sales:				
Back issues of journals	894.50	89.54	643.55	161.41
Mailing lists	231.82	231.82		
Interest earned	87.00	87.00		
Total	110,178.90	16,964.24	80,056.54	13,158.12
Expense				
Printing and mailing:				
FOOD TECHNOLOGY	41,649.28		41,649.28	
FOOD RESEARCH	10,936.39			10,936.39
Advertising sales expense:				
FOOD TECHNOLOGY	13,397.48		13,397.48	
FOOD RESEARCH	39.15			39.15
Circulation expense:				
FOOD TECHNOLOGY	753.56		753.56	
FOOD RESEARCH	977.08			977.08
Discounts	1,380.66		1,329.96	50.70
Rent, telephone and telegraph	2,378.95	1,427.35	713.70	237.90
Stationery, printing and postage	2,931.05	1,758.61	879.33	293.11
Clerical salaries	7,355.00	4,513.00	2,106.50	735.50
Secretary's salary	8,000.00	4,800.00	2,400.00	800.00
General expense	1,188.40	1,188.40		
Payroll taxes	560.93	336.57	168.27	56.09
President's office	65.35	65.35		
Contingencies	386.74	386.74		
Editor's office:				
Salaries	6,216.68		4,144.45	2,072.23
Maintenance	886.46		590.98	295.48
Travel	457.71		305.14	152.57
Contingencies	340.70		227.13	113.57
IFT news program	632.30	632.30		
Expense—sale of back numbers	87.47		65.65	21.82
Travel	927.72	556.64	278.31	92.77
Audit, surety bond and insurance	443.17	265.89	132.96	44.32
Expense—sale of mailing lists	122.87	122.87		
Depreciation	484.05	484.05		
Total	102,599.15	16,537.77	69,142.70	16,918.68
Net Income for Year				
Carried to capital account	7,579.75	426.47	10,913.84	3,760.56*

*Denotes red figure.

CHARES S. LAWRENCE, *Executive Secretary.*

B. Treasurer's Report

Year Ended April 30, 1954

CASH RECEIPTS AND DISBURSEMENTS STATEMENT

Particulars	*Detail*	*Total*
Cash in Bank		
May 1, 1953		$ 61,009.72
Receipts		
Dues		
FOOD TECHNOLOGY:	$28,665.70	
Advertising, non-member subscriptions, manuscript subsidies and back numbers	65,344.89	
FOOD RESEARCH:		
Advertising, subscriptions, manuscript subsidies and back numbers	13,904.59	
Mailing lists sold	231.82	
Proceeds from annual meeting	2,223.03	
Cash sales—directories	89.54	
Interest received	61.00	110,520.57
Total		171,530.29

(Continued on page 12)

DEPENDABLE COLORS
for Discriminating Buyers

- Unlimited production facilities
- Complete technical service

- Accurate blending
- Nationwide distribution

Write us for Prices and Detailed Information.

U.S.P. Vitamins in bulk

Also available in carriers for easy, accurate and economical fortification of foods.

• • •

Roccal—the original quaternary ammonium sanitizing agent.

Sterwin Chemicals INC.

SUBSIDIARY OF STERLING DRUG INC.

1450 BROADWAY, NEW YORK 18, N. Y.
2020 Greenwood Avenue, Evanston, Ill.
WAREHOUSE STOCKS: Rensselaer, N. Y., Evanston, Ill., Los Angeles
FACTORY: CINCINNATI, OHIO

Branch Offices:
Atlanta, Boston, Buffalo, Dallas, Evanston (Ill.), Kansas City (Mo.), Los Angeles, Minneapolis, Portland (Ore.), St. Louis

WORLD'S LARGEST SUPPLIERS OF VANILLIN

(Continued from page 10)

Particulars	*Detail*	*Total*
Disbursements		
FOOD TECHNOLOGY:		
Printing and mailing	$42,172.98	
Advertising sales expense	13,397.48	
Circulation expense	753.56	56,324.02
FOOD RESEARCH:		
Printing and mailing	13,428.83	
Advertising sales expense	39.15	
Circulation expense	977.08	14,445.06
Expense—sale of back issues of journals		87.47
Rent, telephone and telegraph		2,378.95
Clerical salaries		7,355.00
Secretary's salary		8,000.00
Stationery, printing and postage		2,931.05
Travel		927.72
Editor's office		7,901.55
President's office		65.35
Office furniture and equipment		330.22
Auditing, surety bond and insurance		419.06
Expense—sale of mailing lists		122.87
Contingencies		386.74
IFT news program		632.30
General expense—National headquarters		1,188.40
Payroll taxes		560.93
Increase in emblems and certificates		96.35
U. S. Treasury notes		19,948.00
Monsanto Chemical Company award		100.00 124,201.04
Cash in Bank		
April 30, 1954		47,329.25

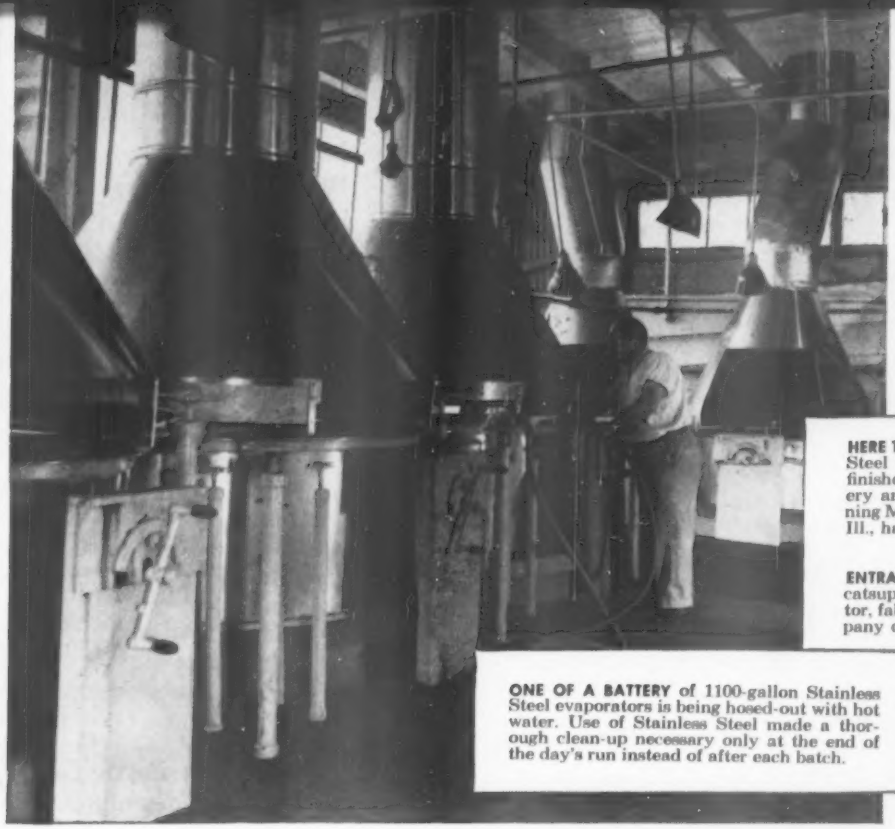
AKSEL G. OLSON, *Treasurer.*

C. 1954-1955 Budget

Receipts		
1. Membership dues	$ 28,645.00	
2. Non-member subscriptions—FOOD TECHNOLOGY	5,565.00	
3. Member subscriptions—FOOD RESEARCH	5,167.50	
4. Non-member subscriptions—FOOD RESEARCH	10,921.22	
5. Advertising income—FOOD TECHNOLOGY (less Agency Commission)	49,000.00	
6. Advertising income—FOOD RESEARCH (less Agency Commission)	570.00	
7. Income from annual meetings	12,000.00	
8. Sale of back issues (FOOD TECHNOLOGY, FOOD RESEARCH and Directory)	600.00	
9. Interest earned	163.00	
10. Miscellaneous receipts	250.00	$112,881.72
Expenditures		
11. FOOD TECHNOLOGY printing and mailing	$ 42,584.48	
12. FOOD TECHNOLOGY circulation expense	800.00	
13. FOOD TECHNOLOGY advertising sales and handling expense	12,250.00	
14. FOOD RESEARCH printing and mailing	10,641.96	
15. FOOD RESEARCH circulation expense	1,000.00	
16. FOOD RESEARCH advertising handling expense	30.00	
17. Back issues sales expense—FOOD TECHNOLOGY and FOOD RESEARCH		
18. Editorial Expense:		
(a) Salaries	7,000.00	
(b) Maintenance	1,000.00	
(c) Travel	700.00	
(d) Contingencies	500.00	
19. Rent, telephone and telegraph	2,400.00	
20. Stationery, printing and postage	3,000.00	
21. Clerical expense	8,100.00	
22. Taxes	600.00	
23. Secretary's salary	9,000.00	
24. President's office	600.00	
25. Office furniture and equipment	500.00	
26. General expense—National headquarters	1,200.00	
27. Travel	1,200.00	
28. Contingencies (President's fund)	500.00	
29. Audits, surety bond and insurance	600.00	
30. Annual meeting expense	6,000.00	
31. IFT news program	750.00	$110,956.44

(Plus—$1,925.28)

—Report of the Financial Committee to the Council, June 27, 1954.



HERE THE FLOW of catsup to a Stainless Steel finisher is being shut off. The finisher, fabricated by Food Machinery and Chemical Corporation's Canning Machinery Division at Hoopeston, Ill., has been in use about 10 years.

ENTRAPPED AIR is removed from the catsup in this Stainless Steel deaerator, fabricated by the Chain Belt Company of Milwaukee, Wisconsin.

ONE OF A BATTERY of 1100-gallon Stainless Steel evaporators is being hosed-out with hot water. Use of Stainless Steel made a thorough clean-up necessary only at the end of the day's run instead of after each batch.

To preserve the high quality the name stands for...

Crosse & Blackwell

FINDS YOU CAN'T BEAT STAINLESS STEEL!

● The Crosse & Blackwell Company, Baltimore, Md., carries on a tradition of quality in specialty foods established by the English company of the same name. And for sanitation and protection of products, the Baltimore firm makes the fullest use of Stainless Steel equipment.

Processing of tomato catsup, for example, is almost a 100% Stainless Steel operation. Pulp enters eight Stainless Steel evaporators through Stainless Steel pipe; condiments are added and it is cooked. These evaporators were put into service in 1939 replacing equipment of other material which lasted four or five years at the most. Stainless Steel's smooth, pit-free surface makes cleaning after each batch unnecessary; a thorough cleaning at the end of the day's run is enough.

From the evaporators, catsup flows by gravity through Stainless pipe to a Stainless Steel finisher. From the finisher it goes—again through Stainless pipe—to a deaerator made of Stainless Steel. Here it is put under 16-inch vacuum and any entrapped air is removed.

The final step is a Stainless Steel bottle filling machine that has given satisfactory service since its installation approximately 10 years ago.

For prevention of contamination, ease of cleaning and long life with little maintenance, Stainless Steel equipment can't be surpassed. And for the finest possible performance, insist that your processing equipment be fabricated from perfected, service-tested USS Stainless Steel.

UNITED STATES STEEL CORPORATION, PITTSBURGH • AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS STAINLESS STEEL

SHEETS • STRIP • PLATES
BARS • BILLETS

USS

PIPE • TUBES • WIRE
SPECIAL SECTIONS

UNITED STATES STEEL

How to make a better shortening with ¾ less emulsifier

You need only a quarter as much Myverol® Distilled Monoglycerides in your shortening as compared with the usual mono- and diglyceride mixtures.

That's because Myverol is so pure you need very little and you can add it after your deodorization process without affecting the color, flavor, or odor of your product. You don't first introduce a lot of emulsifier and then lose much of its effectiveness in the deodorizer. The use of a small quantity of the pure material not only saves money but also results in much less depression of smoke point and much less odor when the shortening is heated in use. You have absolute control of the emulsifier content in the finished shortening.

Myverol Distilled Monoglycerides, Type 18-85, is a wholesome food made from refined cottonseed oil. Type 18-40 is another such wholesome food made from prime steam lard. With diglycerides and impurities removed by DPi's own unique molecular distillation process, either can put your product in line with today's time- and work-saving ideas on how a shortening should behave in plant and kitchen.

To find out how Myverol Distilled Monoglycerides can improve your product and processes just let us know how much of a free sample you will need for testing. Write ***Distillation Products Industries,*** Rochester 3, N. Y. Sales offices: New York and Chicago • W. M. Gillies and Company, Los Angeles and San Francisco • Charles Albert Smith Limited, Montreal and Toronto.

distillers of monoglycerides made from natural fats and oils

DPi Also . . . vitamins A and E

Distillation Products Industries
is a division of **Eastman Kodak Company**

Plans for Fifteenth Annual Meeting of IFT at Columbus, Ohio, June 12-16, 1955, Well Under Way

Delegates to the Fifteenth Annual Meeting of the Institute of Food Technologists will converge on the great Middle West, the great State of Ohio, and arrive at the great city of Columbus on or before June 12, 1955. General Chairman H. D. Brown has the total plan of the meetings well in hand and has begun implementing those phases that can be handled well in advance of the meeting.

Call for papers. The 1955 Program Committee met in Los Angeles and set up the following schedule of Sections for the 1955 meeting. The Section chairmen will serve as the 1955 Program Committee with George Garnatz, Kroger Food Foundation, Cincinnati, and F. E. Deatherage, The Ohio State University, Columbus as co-chairman.

Meats—W. J. Shannon, Oscar Mayer Packing Co.

Sensory Testing—To be filled.

Vegetables—Charles H. Mahoney, National Canners Assoc.

Poultry and Eggs—George F. Stewart, U. of California.

Microbiology—J. C. Ayres, Iowa State College.

Packaging—Robert A. Farrell, Marathon Corporation.

Quality Control—Roy E. Morse, Wm. E. Stange Co.

Process Control and Engineering—F. K. Lawler, Food Engineering.

Fermentation Products—W. B. Esselen, Jr., U. of Massachusetts.

Fruits—R. D. Gerwe, Food Machinery Corp.

Functional Value of Food Additives—Bernard L. Oser, Food Research Laboratories, Inc.

Canning and Processing—Charles L. Smith, Continental Can Co.

Fats and Oils—Harry J. Deuel, U. of Southern California.

Research Papers—Hans Lineweaver, Western Utilization Research Branch, U.S.D.A.

Conferences and Round Table Discussions—Z. I. Kertesz, N. Y. State Agricultural Expt. Station.

Miscellaneous Papers.

Arrangements are being made for only four simultaneous sections on Monday, Tuesday and Wednesday which will not conflict with plant trips or conference and discussion groups. Those groups which were organized unofficially for the Los Angeles meeting for special interest areas will be announced as part of the official program and regularly scheduled in the late afternoons and all day Thursday.

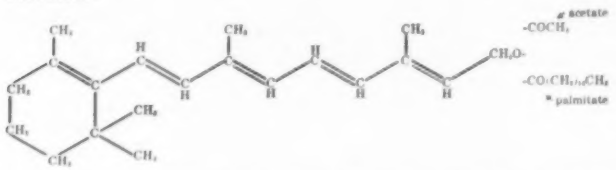
Institute members will be permitted only one contributed paper. Papers will be accepted in order of receipt. Additional papers may be submitted and will be accepted as the schedule permits. A paper submitted by a non-member must be introduced by a member; papers by Institute members will have priority over

(Continued on page 16)

Notes from the makers of
Myvax Vitamin A

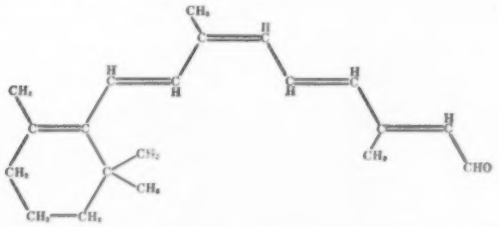
Vitamin A in the dark

This is the active, principal, and vital ingredient in the Myvax Vitamin A which we make in bulk and put up as Myvapack Vitamin A for the individual requirements of margarine manufacturers:



That it helps people and animals grow properly and maintain their epithelial tissues in sound condition has long ago passed out of the area of doubt. Instead of just taking these wonderful attributes for granted, we maintain a staff of organic chemists, biochemists, and biologists who keep busy putting out papers, correspondence, and samples to their scientific colleagues interested in exploring the molecular architecture represented above.

It turns out, for example, that in the body some of the vitamin A develops a twist and turns up in the retina of the eye in a *cis* form of the aldehyde, possibly:



In the dark this—and only this—combines with the protein opsin to form the pigment rhodopsin. The action of light in bleaching the rhodopsin back to vitamin A aldehyde and opsin is responsible for our ability to see in dim light. The strange thing is that when the vitamin A aldehyde comes out of the rhodopsin it is back in the straight, all-*trans* form preferred by nature's and man's synthetic processes.

It is not at all strange that the famous university biologist who reported this turned to us for certain of the data and experimental preparations of vitamin A isomers which he needed in his research. Doing and assisting basic research we regard as part of the responsibility that comes to us as old hands in the vitamin A field.

The rest of the responsibility is to keep the quality of Myvax Vitamin A at the top and the service flawless in promptness and convenience to customers old and new. This, too, we never shirk. ***Distillation Products Industries,*** Rochester 3, N. Y. Sales offices: New York and Chicago • W. M. Gillies and Company, Los Angeles and San Francisco • Charles Albert Smith Limited, Montreal and Toronto.

"Myvax" and "Myvapack" are trade-marks.

leaders in research and production of vitamin A

DPi

Also . . . vitamin E . . . distilled monoglycerides . . . more than 3500 Eastman Organic Chemicals for science and industry

Distillation Products Industries *is a division of* **Eastman Kodak Company**

Plans for the Fifteenth Annual Meeting of IFT at Columbus, Ohio, June 12-16, 1955, Well Under Way

(Continued from page 14)

those by non-members. Most papers will be scheduled for 12 to 15 minutes including discussion and *the final program time schedule will be rigidly followed.*

All desiring to present papers or to organize or participate in discussion groups for the 1955 meeting in Columbus, June 12-16, must send in the following information, properly typed out, together *with an additional carbon copy.* This must be in by *November 15, 1954.* Complete abstracts will be called for by February 1, 1955.

To: F. E. Deatherage
Dept. Agricultural Biochemistry
The Ohio State University
Columbus 10, Ohio

1. Authors (Underline non-members and indicate introducing member if only non-members are authors):
2. Name and address of Institution or Company Affiliation:
3. Title:
4. Statement indicating nature of paper (100 words or less).
5. Section preference:

If you are interested in discussion groups or round tables please indicate:
Subject:
Suggested leader:
Your name:
Your address:

The host committee. Names and addresses of the committee members, selected from the Ohio Valley Section of IFT, host of the meetings, are:

General Chairman
H. D. Brown
Horticulture Department,
The Ohio State University (O. S. U.)
Columbus 10, Ohio

Associate Chairman
J. B. Brown
Physiological Chemistry, O. S. U.
Columbus 10, Ohio

Secretary
M. Eloise Green
School of Home Economics, O. S. U.
Columbus 10, Ohio

Technical Program
Fred Deatherage, *Co-Ch.*
Agr. Bio. Chem., O. S. U.
Columbus 10, Ohio

George Garnatz, *Co-Ch.*
The Kroger Co.
Cincinnati 4, Ohio

Exhibits
Norbert Volle
The Kroger Co.
Cincinnati 4, Ohio

Banquet
Rees Davis
Hort. Dept., O. S. U.
Columbus 10, Ohio

Courtesy and Hospitality
Dan McCoy
Frigidaire
Dayton 1, Ohio

Entertainment
Alden Winter
Poultry Dept., O. S. U.
Columbus 10, Ohio

Housing
C. B. Tibbits
Taylor Instrument Co.
81 E. State St.
Columbus 15, Ohio

Printing
Dan Ridenour
Anchor Hocking Glass Corp.
Lancaster, Ohio

Publicity
Wilbur Gould
Hort. Dept., O. S. U.
Columbus 10, Ohio

Registration
Velt Stafford
The Kroger Co.
Columbus 3, Ohio

Tours
Fred H. Dellwo, *Ch.*
Ball Bros. Co.
Muncie, Ind.

O. F. Garrett, *Co-Ch.*
M. & R. Dietetics Lab.
Columbus, Ohio

Finance
Ratcliff Robinson, *Ch.*
Battelle Memorial Inst.
505 King Ave.
Columbus, Ohio

R. C. Overbeck, *Asst. Ch.*
Battelle Memorial Inst.
505 King Ave.
Columbus, Ohio

Women's Entertainment
Inez Prudent
School of Home Econ., O. S. U.
Columbus 10, Ohio

Regional Section News

MARYLAND SECTION

Thirty-eight members and guests were present at the June Meeting of the Maryland Section, which was held at the Stafford Hotel, Baltimore, on Friday, June 11, 1954.

The Section was fortunate in having for its speaker, the eminent barrister, Mr. Vincent A. Kleinfeld, who addressed the group on the subject of "Food Additives." Mr. Kleinfeld, a former lawyer for the Food and Drug Administration, former chief counsel for the Delaney Committee, author of many tomes on the Food and Drug Act, is presently in private practice. In addition to the latter, he teaches Food and Drug law at both New York and Georgetown Universities.

Mr. Kleinfeld pointed out the need for new legislation with respect to the Food, Drug and Cosmetic Act to provide for adequate safeguards for the consumer. He stated that he favors a "new foods section" in the Act similar to the present "new drugs section" which is in the Act. The latter requires that a manufacturer must prove beyond a reasonable doubt that a new drug does not have a chronic toxic effect on warm-blooded animals before he is allowed to market the product. He said that the theory of "safety by assumption" is not enough in itself and used as illustrations the following materials which were in general use, but because of reasonable doubts have been withdrawn from the market except in special instances when they may be used as prescribed by a physician:

Coumarin—a flavoring in ice creams and syrups.
Lithium Chloride—a salt substitute.

(Continued on page 20)

See How You Can Save with Modern, Specialized FMC Can Handling Equipment

THE FMC "STACKMATIC" PALLET UNLOADER *automatically and continuously unloads bright cans from pallets, single-files them to labelers at 600 or more cans per minute.*

FMC's NON-SHOCK CASER *automatically cases cans fast (up to 1,200 cases per hour)—limited only by the speed of the operator. It's gentle to cans, labels and products, cuts costs.*

Write for full information, or call your nearest FMC representative

If you move canned products in any volume, it will pay you to get acquainted with the *specialized* FMC Can Handling Equipment shown or briefly described here. Each piece has been specifically designed and engineered to:

1. Speed up canning line operations
2. Cut handling costs and manpower
3. Provide smooth, uniform handling
4. Eliminate can and product damage

These are a few of the many ways you save with FMC Can Handling Equipment—savings that help build bigger profits for you! And once you've installed this equipment, you're in for the added benefits of low operating and maintenance costs through years of continuous service.

You can *rely* on FMC for quality.

OTHER FMC CAN HANDLING EQUIPMENT

- **FMC AIR BLAST CAN DRYER** literally blasts cans dry at speeds up to 450 cpm, depending on can size. Permits immediate labeling and casing.
- **FMC KYLER CASER,** motor driven and hand operated models, combine simplicity and ruggedness, are efficiently adaptable to small capacity operations.
- **FMC KYLER LABELERS** apply spot or wrap-around labels on any type of round container with high speed and accuracy. Adjustable and non-adjustable models.
- **FMC CAN UNSCRAMBLER** speeds up delivery of filled cans from retort crate or shipping case to labeler or cuser.
- **FMC UNIVERSAL CAN WASHER** quickly and thoroughly removes all dirt, dust and grime accumulated in empty cans through storage and handling.

Key to food equipment

fmc FOOD MACHINERY AND CHEMICAL CORPORATION

FOOD MACHINERY AND CHEMICAL CORPORATION

Canning Machinery Division

General Sales Offices:

WESTERN: SAN JOSE, CALIFORNIA **EASTERN:** HOOPESTON, ILLINOIS

One of a series of favorite American meals brought to you by the American Can Company

Hearty eaters everywhere will love this

NORTHWOODS LUMBERJACK FAVORITE

Solid eating—so simple to fix—
when you use today's finest-ever canned foods!

American Can Company not only perfected the modern food container . . . it also developed many of the canning processes that today bring you real *on-the-spot* flavor and even more vitamins than you often get in "fresh" varieties.

Lumberjacks have a knack with stick-to-the-ribs food. Stew is a favorite. Not just plain stew—rich meat often with chicken, Limas, zesty seasoning.

They simmer it for hours. *You* can match it in minutes, easy as rolling off a log—by using ingredients that come in Canco cans made by American Can Company.

You don't even have to peel apples to make a pie for dessert. They come in cans, too. All this convenience doesn't cost a penny. You actually *save* money.

The price *of* canned foods in recent years has risen far less than other foods. One reason is American Can's leadership in developing special linings which not only protect flavor, but permit use of *less* tin, thus helping you to eat better for less money.

Try this hearty, thrifty "feed" on *your* men!

NORTHWOODS LUMBERJACK STEW

2 cans (1½ lb. each) or 3 cans (1 lb. each) beef stew
1 can (14 or 16 oz.) chicken fricassee
1 can (1 lb.) Lima beans, drained
½ cup chili sauce
2 tablespoons grated onion
1½ teaspoons Worcestershire sauce
½ teaspoon garlic salt

Combine all ingredients; simmer 10 minutes, stirring carefully.

HOT BISCUITS

Bake refrigerated prepared biscuits according to label directions. Reheat over grill in covered pan or aluminum foil, if desired.

APPLE PIE

For crust: Prepare *pastry* for two-crust 9-inch *pie, using your favorite shortening.*

For filling:
2 cans (1 lb. 4 oz. each) sliced apples
½ to ¾ cup sugar
1 tablespoon canned lemon juice
2 tablespoons flour
1 teaspoon cinnamon and ½ teaspoon nutmeg or 1½ teaspoons apple pie spice
1 tablespoon butter or margarine

Drain apples, reserving ⅓ cup juice. Combine apples, reserved juice, sugar, lemon juice, flour and spices. Turn into pastry-lined pan; dot with butter or margarine. Cover with top crust; seal. Bake in hot oven (425°F.) 45 to 50 minutes. Serve with cheese. Makes one 9-inch pie.

BEER • ALE

For greatest convenience buy beer and ale in non-returnable cans . . . the Canco cans trademarked *"Keglined."*

These recipes serve 6. You may use can weights that vary slightly from those given here. Recipes were developed in Test Kitchens of American Can Company.

Important Note: Whenever you do not use a full can of food . . . cover and keep the remainder in the refrigerator *right in the can.* It's safe—and it's sensible!

●

NEW! "Food for Entertaining—Better with Beer"

Send for 20-page booklet of quick, clever ideas for TV suppers, buffets and casseroles featuring foods that are specially good with beer. Mail 15¢ to American Can Company Test Kitchens, Box 239, New York 40, N. Y.

American Can Company

Containers to help people live better

Registered Trademark of the American Can Company, N.Y., N.Y.

Look closely—there are profit dollars for YOU ← in this ad!

Millions of homemakers are always on the lookout for just the kind of tasty, easy-to-prepare meal you see pictured in the ad at your left.

Come September 13th, they'll see "Northwoods Lumberjack Favorite" in delectable full color in LIFE magazine. (In fact, this Canco ad will appear before an audience of 26,450,000!)

Thus, many meal planners will soon do their shopping with this picture of stew, beer, apple pie and other good things still in their minds. Here's where you come in—*it's a golden opportunity for you to cash in!*

Remind your buyers to take full advantage of this campaign by encouraging retailers to *price attractively* and *display prominently* the items featured in the ad.

By showing meal planners how to prepare delicious, economical meals from canned foods, Canco actually *creates a buying urge*—and helps build the prestige of *all* canned foods and beverages. That means profit for you—*if you cash in on it!*

With this series of colorful consumer ads, Canco continues to *help you sell more in '54.*

Go first to the people who are first!

AMERICAN CAN COMPANY

CANCO

New York, Chicago, San Francisco; Hamilton, Canada

FREE! Mats or photographs for newspaper advertising . . .

To help YOU get YOUR brand featured in food retailers' newspaper ads, Canco has mats of the main illustration of this LIFE ad (2 col., 65 screen) for any tie-in program you may work out with your retailer. A mat or photograph will be sent, FREE, direct to any retailer planning such promotion. Requests should be addressed to:

American Can Company
Sales Promotion Division
100 Park Avenue
New York 17, New York

65 screen halftone mats (2 col. x 4⅞"—136 lines) or 8 x 10 glossy photo available.

REGIONAL SECTION NEWS

(Continued from page 16)

Dulcin—a synthetic sweetener.
Chloromycetin—an antibiotic.

He told the group that he felt sure that Congress would enact the remedial legislation.

Mr. Kleinfeld's remarks were by no means received in passive silence by the members of the Section, but rather sparked a most entertaining question-and-answer period, in which the speaker's talents as an attorney were taxed to the limit by both the "longhair" and practical-minded group present.

AUSTRALIA NORTHERN SECTION

The Australia Northern Section was host at the Fourth Annual Convention of the Australian Sections of IFT which was held at Leura in the Blue Mountains

Secretary of the Australia Southern Section, Miss M. K. Paxton (H. J. Heinz Co.) talking with the Secretary of the Australia Northern Section, Dr. V. M. Lewis (Henry Lewis & Sons Pty. Ltd.) at the Fourth Annual Convention of the Australian Sections of IFT.

region of New South Wales in May. Resident attendance at the Convention was over 150. The program was as follows:

May 26th:
Cocktail party and buffet dinner.

May 27th:
Morning—General Session.
Afternoon—Golf, Tennis, Sightseeing.
Evening—Official Dinner, Guest Speaker: Dr. W. A. Westerman.

May 28th:
Morning—Session on Quality Control. Concurrent Ladies' Session for wives and visitors.
Afternoon—General Session.
Evening—Social Hour and filming of 1953 Davis Cup Tennis.

May 29th:
Session on Packaging.

Besides the technical papers, an exhibit of packaging methods and materials was arranged, and a demonstration of taste testing techniques was organized by the C.S.I.R.O. Division of Food Preservation.

PERSONNEL

Professor Amihud Kramer, College of Agriculture, the University of Maryland, has been granted a leave of absence of one year from the University of Maryland to undertake an assignment with the United States Operations Mission to Israel as advisor on food distribution and preservation problems. His address overseas will be c/o United States Embassy, U.S.O.M., Tel Aviv, Israel.

Masters and Doctors in Food Technology

THE OHIO STATE UNIVERSITY

Name	*Degree*	*Thesis or Dissertation*
Billig, Eleanor	M.S. (1953)	Baking Qualities of Butter as Affected by the Manufacturing Process and Addition of an Emulsifying Agent
Cooper, J. Paul	M.S.	Consumer Acceptance of Ice Cream as Affected by Composition and Flavor Differences
Cotteril, Owen J.	Ph.D.	Influence of Lysozyme on Egg White Quality
DeWeese, Duane	M.S.	Color, Flavor and Texture Evaluation of Raw and Frozen Peaches Held under Varying Storage Conditions
Duvernay, Gilbert	M.S.	Consumer Evaluation of Selected Qualities of Cream Style Corn and Tomato Juice
El-Hagarawy, Ibrahim S.	Ph. D. (1953)	Factors Affecting the Organic Acid Production by Proprionic Bacteria in the Manufacture of Swiss Cheese
Hintz, Philip C.	M.S. (1953)	Some Fatty and Free Amino Acids Found in Commercial Swiss Cheese
Hunt, Fern	M.S.	Physical Properties of Cake as Affected by Method of Butter Manufacture and Addition of an Emulsifying Agent
Jencks, Sarah	M.S. (1953)	Consumer Reaction to Milk Varied in Fat and Solids-Not-Fat Composition
Kennerly, Carl D.	M.S. (1953)	Effect of Methods of Blanching and Cooling on the Drained Weight of Frozen Vegetables
Kojima, Nakaji	M.S. (1953)	The Effects of Iodized Salt in Processed Fruits and Vegetables
Mavis, James O.	M.S. (1953)	Color Measurement of Tomato Puree
Reisfeld, Ralph A.	M.S. (1953)	Factors Affecting the Manufacture of a Low Fat, Soft Ripened Cheese
Shields, Patricia	M.S. (1953)	The Influence of Thermostabilization of Shell Eggs on the Functional Properties of Egg Whites
Stephens, Jane Aletha	M.S. (1953)	Establishment of a Consumer Preference Panel for the Evaluation of Food Products
Vandersall, John H.	M.S.	The Use of Liver Biopsy Techniques in a Study of Factors Unrelated to Vitamin A Intake Which Influence Plasma Vitamin A and Carotene Levels
Schwartz, Daniel P.	Ph.D.	Lipolytic Enzyme System of Milk

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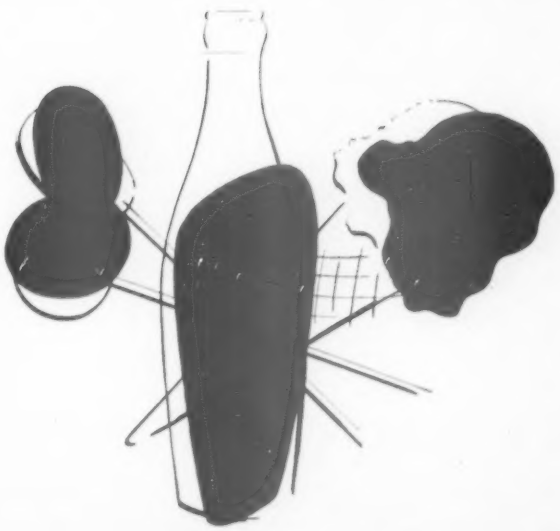

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Selected Abstracts*

ANALYTICAL METHODS

Estimating carbonyl compounds in rancid fats and foods.

HENICK, A. S., BENCA, M. F., AND MITCHELL, J. H. *J. Am. Oil Chemists' Soc., 31,* 88-91 (1954).

A convenient method for the quant. dctn. of the carbonyl compds. in fats and oils is described. It is based upon the formation of the 2,4-dinitrophenyl hydrazones of the carbonyl compds. in the presence of trichloroacetic acid catalyst and the colorimetric dctn. of the hydrazone compds. in the alk. soln.

Trace elements and changes in fats.

GORBACH, G. *Fette u. Seifen, 55,* 541-4 (1953); *Fats, Oils, Det., 11,* 215 (1954).

Traces of metals in fats and oils are detd. by dissolving the org. material in an org. solvent and extg. with 15% HCl. After evapn. of the soln., traces of metals can be detd. colorimetrically or spectroscopically.

A technic for analysis by countercurrent extraction.

COOKSON, M. A., AND LANEY, D. H. *Chemistry & Industry,* 450-2 (1954).

A method by which the technic of countercurrent distribution may be carried out with simplified app. is described. Six ordinary sepg. funnels are used.

BIOLOGICAL SCIENCES

BIOCHEMISTRY

Effect of atabrine on x-irradiation-induced leucopenia in chick, rat and mouse.

KELLEY, B., SIMMONS, M. R., DAY, P. L., MESCHAN, I., AND DOUGLASS, C. D. *Proc. Soc. Exptl. Biol. Med., 85,* 460-2 (1954).

Supplementation of the diets of chicks with atabrine tends to reduce markedly the severity of post-irradiation leucopenia. Atabrine administration to rats and mice may alter the post-irradiation leucopenia slightly.

Mouse-strain differences in response to radiation.

REINHARD, M. C., MIRAND, E. A., GLOTZ, H. L., AND HOFFMAN, J. G. *Proc. Soc. Exptl. Biol. Med., 85,* 367-70 (1954).

The acute radiation mortality of mice exposed to x-rays shows that there are radiosensitive regions in the mouse head. The L. D. —50% at 12 days for acute mortality due to whole-body exposure to x-rays is essentially the same for 4 mouse strains and is about 528 r. The sensitivity of the head region varies with mouse strain. Up to more than a 4-fold decrease in head sensitivity in the strains is found.

Glucuronic acid conjugates of aspartic and glutamic acids in urine.

POLLACK, R. L., AND EADES, C. H. *Science, 119,* 510-11 (1954).

It was reported that when amino acids were excreted in the urine only 1% of the aspartic acid and 10% of the glutamic acid were present in the free state. Evidence is presented that aspartic and glutamic acids occur in urine, at least in part, as glucuronic acid conjugates.

Identification of C-terminal residues in peptides and proteins through formation of thiohydantoins.

TURNER, R. A., AND SCHMERZLER, G. *Biochim. et Biophys. Acta, 13,* 553-9 (1954).

The thiohydantoin method is applicable to the stepwise degradation of peptides and proteins on a small scale. While the method is generally successful for most of the common, neutral amino acids, it fails when the C-terminal residue is serine or proline, or when the residue is aspartic acid, glutamic acid, lysine, or arginine.

Effect of temperature and pH on the optical rotation of proteins.

GOLUB, M. A., AND PICKETT, E. E. *J. Polymer Sci., 13,* 427-40 (1954).

It was found that the proteins showed little or no effect of temp. on the optical activity whether in the native or denatured state. Where definite changes in rotation occurred among the native proteins, these were attributed to denaturation accompanying the change of temp.

Some reactions between inert dusts and proteins.

HOUMAN, R. F. *Arch. Ind. Hyg. and Occupational Med., 9,* 284-90 (1954).

Assuming that the fluid bathing the lung alveoli has properties similar to blood serum, positively charged particles may be expected to cause coagulation where they settle in the alveoli. A suitable mixed dust will cause coagulation under a variety of circumstances, while there are dusts, such as cement, which may not be expected to react with proteins.

NUTRITION

Relation of fat and caloric intake to atherosclerosis.

GOFMAN, J. W., TAMPLIN, A., AND STRISOWER, B. *J. Am. Dietet. Assoc., 30,* 317-26 (1954).

The restriction of dietary fat will result in the lowering of certain classes of lipoprotein levels and of atherogenic index values. However, no good evidence has yet accumulated to suggest the mechanism by which the effect is achieved. The question arises as to whether the effect is being achieved by restriction of the fat itself or by restriction of some as yet unidentified dietary constituent assocd. with dietary fat.

Vitamin B_6, its fundamental role in nutrition.

VILTER, R. W. *Merck Report, 63,* 6-10, April, 1954.

A review article.

PHARMACOLOGY AND TOXICOLOGY

Analyses of biological materials as indices of exposure to organic solvents.

ELKINS, H. B. *Arch. ind. Hyg. and Occupational Med., 9,* 212-22 (1954).

Dctn. of urine sulfate ratios is a proved method of evaluating exposure to benzene vapor. Analysis of urine for the proper solvent or metabolite is helpful in estg. exposure to MeOH, methyl acetate, toluene, and trichloroethylene and undoubtedly absorption of aniline as well. Dctn. of blood Br is useful in connection with exposures to CH_2Br, methylene chlorobromide and probably other org. bromides.

A toxicological evaluation of household insecticides.

LEHMAN, A. J. *Assoc. Food & Drug Officials U. S., 18,* 3-13 (1954).

Considered are: acute, dermal, inhalation and chronic toxicity. Special considerations are given to 9 insecticides in current use.

An in vitro study of various commercially available bulk-type laxatives. III. Physiochemical measurements of their influence upon the digestion of a carbohydrate, a fat, and a protein.

BONE, J. N., AND RISING, L. W. *J. Am. Pharm. Assoc., Sci. Ed., 43,* 312-14 (1954).

The results indicate that many of the bulk-type laxatives studied retard the digestion of a carbohydrate and a protein and accelerate the digestion of a fat.

Protective effect of liver residue on immature male rats fed toxic doses of acetylsalicylic acid.

ERSHOFF, B. H., MCWILLIAMS, H. B., AND THURSTON, E. W. *J. Am. Pharm. Assoc., Sci. Ed., 43,* 175-7 (1954).

Administration of H_2O insol. liver residue largely counteracted the growth retardation and reduction in thymus, prostate, and seminal vesicle wt. of immature male fed toxic doses of acetylsalicylic acid. The protective factor(s) was distinct from any of the known B vitamins and was not present in significant amts. in purified casein.

(Continued on page 24)

* These Selected Abstracts are made available to FOOD TECHNOLOGY through the cooperation of Associate Editor H. A. Campbell and the General Foods Corporation of New York, N. Y. The abbreviations found in these abstracts are similar to those used by Chemical Abstracts.

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SELECTED ABSTRACTS

(Continued from page 22)

Studies on the nutritive values of lipids. VIII. Nutritive value or toxicity of highly unsaturated fatty acids (I).

KANEDA, T., AND ISHII, S. *Bull. Japan. Soc. Sci. Fisheries, 19,* 171-7 (1953); *Biol. Abstr., 28,* 1029, No. 10473 (1954).

Highly unsatd. fatty acids retard growth and have a toxic effect when fed to rats. Careful expts. showed that rats would take highly unsatd. acids from sardine oil without distaste or ill effect, while oxidized products of the same acids caused the rats to die.

New blood expander.

Science News Letter, 65, 307 (1954).

A microbe from the soil, *Bacillus subtilis,* yields a chemical which becomes a cross-linked glutamyl polypeptide, reported 10 times more effective than serum albumin.

ENGINEERING AND PLANT EQUIPMENT

Take a fresh look at citric.

Chem. Eng., 61, 120°, May, 1954.

A new deep fermentation process for the production of citric acid has been developed by the Dutch pharmaceutical and chemical firm, Noury & Van der Lande. The advantages claimed are a wide flexibility of feed stocks, a high yield fermentation system and an efficient recovery system.

Statistical design.

YOUDEN, W. J. *Ind. Eng. Chem., 46,* 111A-14A, April, 1954.

This article points out that statistical technics not only enter at the end of the work but are most productive when incorporated into projects at the planning stage.

FOOD AND FOOD TECHNOLOGY

DESSERTS

Vanilla, strawberry, chocolate top three flavors in Canada.

Ice Cream Trade J., 50, 117, March, 1954.

Fifty flavors were reported for Canada. Vanilla was the top flavor with 55.09, strawberry was second with 7.86 and chocolate was third with 6.73%. On the sherbet side, orange was first with 63.42, pineapple second with 12.93 and lime third with 10.38%.

FLAVORS AND FLAVORING

Ultraviolet absorption spectra of coumarin derivatives.

GOODWIN, R. H., AND POLLOCK, B. M. *Arch. Biochem. Biophys., 49,* 1-6 (1954).

The u. v. absorption spectra of EtOH solns. of coumarin and 18 of its derivs. are reported.

Paper chromatography in the qualitative and quantitative analysis of organic flavoring compounds.

HEIDE, R., AND LEMMENS, J. F. *Perfumery Essent. Oil Record, 45,* 21-3 (1954).

A method is described for complete sepn. of mixts. contg. vanillin, methyl-vanillin, ethylvanillin, helitropin, vanitrope and coumarin. After the chromatographic prepn. each compd. is quantitatively detd. by measuring the u.v. absorption spectra.

MEAT

The use of antibiotics in meat processing.

WEISER, H. H., KUNKLE, L. E., AND DEATHERAGE, F. E. *App. Microbiol., 2,* 88-94 (1954).

Exploratory work indicates: (1) antibiotics may be used in meat processing and (2) whole animals may be processed by infusion prior to dressing out.

MILK AND MILK PRODUCTS

The mechanism of sunlight flavor formation in milk with special reference to methionine and riboflavin.

PATTON, S. *J. Dairy Sci., 37,* 446-52 (1954).

It was concluded that the amino acid methionine is a specific source of the flavor. It is suggested that casein is most important as an origin, since it is present in greatest concn., contains the highest level of methionine, and is the principal component limiting light transmission. It is shown that riboflavin is of considerable significance in the production of sunlight flavor in milk.

Sodium-free milk.

CHANEY, A. L. *Chem. Eng. News, 32,* 1568-9 (1954).

Ion exchange technic used on either whole or low-fat milk produces Na-free milk for use of patients on low-Na diets. Na replaced by K under conditions in which other elements remain unaltered in concn.

PECTIN

Kinetics of alkaline hydrolysis of pectinic acids.

KATACHALSKY, A., AND FEITELSON, J. *J. Polymer Sci., 13,* 385-92 (1954).

The second order rate const. of alk. hydrolysis of pectinic acid salts decreases rapidly with the progress of the reaction and shows a pronounced pos. salt effect. This behavior is interpreted in terms of an electrostatic repulsion factor and an "intrinsic" rate const. characteristic of the hydrolyzable groups.

PRESERVATION AND STERILIZATION

Preservation of foods with ionizing radiations.

HANNAN, R. S. *Nature, 173,* 752-4 (1954).

A summary is presented of the symposium held on February 10, 1954 in Cambridge, England to discuss the use of radiations for killing microorganisms in food.

Recent experiments in radiation sterilization of foods.

PRATT, G. B., AND EKLUND, O. F. *Quick Frozen Foods, 16,* 50-1°, May, 1954.

The results indicate no serious deterioration in quality during storage of radiation sterilized meats, but the off flavors developed by the radiation continue to present an obstacle to com. application.

A fungistatic substance extracted from vitrain.

SCHENCH, N. C., AND CARTER, J. C. *Science, 119,* 213-14 (1954).

Examn. of coal from northern and southern Illinois mines revealed that all of them contained sol. material fungistatic in nature. The method proposed by Evans was used.

Refrigeration retained quality in peanut candies.

Peanut J., 23, 18°, April, 1954.

Peanut candies may be kept fresh for as long as 2 yrs. when properly packaged and stored at 0° F. When temps. above 0° F. were used the storage life was proportionately shorter.

ORGANIC CHEMISTRY

Distinction between flavone-glycosides and flavones.

LEU, R., AND HAGEDORN, P. *Z. Anal. Chem., 139,* 96-8 (1953); *Anal. Abstr., 1,* No. 588 (1954).

Color tests are given for rutin, quercetin, morin, quercitrin and hyperoxide.

The structure of cafestol.

HAWORTH, R. D., JUBB, A. H., AND MCKENNA, J. *Chemistry & Industry,* 104 (1954).

The mol. formula and chem. properties suggest a deterpenoid rather than a steroid structure, and cafestol contains 4 carbocyclic rings in addn. to the furan ring. The suggestion by Djerassi appears to be excluded by the u.v. absorption characteristics.

Insect repellents. I. Esters of mandelic and substituted mandelic acids.

BARTHEL, W. F., LEON, J., AND HALL, S. A. *J. Org. Chem., 19,* 485-9 (1954).

Substitution of methoxy, methylenedioxy, or Cl in the ring or acylation or benzoylation of the α-hydroxy group decreased or

(Continued on page 26)

The greatest improvement in leavening agents in years... PY-RAN

FACT 1: **What PY-RAN does for you** . . . gives leavening *stability* never before possible.

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SELECTED ABSTRACTS

(Continued from page 34)

destroyed the repellent effect. The max. repellent effect was observed with simple alkyl esters of mandelic acid contg. 6 carbons or less. Most of the esters described are new compds.

PACKAGING

Food coatings: permeability of acetostearin products to water vapor.

Lovegren, N. V., and Feuge, R. O. *J. Agr. Food Chem., 2,* 558-63 (1954).

Measurements were made at various temps. and relative humidities using films of different compns. and thicknesses. From these data permeability consts. for these fat films were not independent of the thickness of the film or the concn. of H_2O vapor. The permeability of acetostearin films to H_2O vapor is less than that of cellulose acetate and slightly greater than the permeability of nylon, ethyl-cellulose, and polystyrene. Cellophane and parafin wax have significantly smaller permeabilities.

Polyethylene-coated cellophane.

Swec, L. F., and Sullivan, G. H. *Modern Packaging, 27,* 203-8+, March, 1954.

A combination of 2 of the most important transparent films in the packaging industry, combines the best properties of these films into a single low-cost material. Tech. and economical data included in table form.

Saran-coated cellophane.

Modern Packaging, 27, 80-3+, April, 1954.

This material combines the economy and easy-handling characteristics of cellophane with the protective properties of the plastic resin. Tables of properties and characteristics given.

Desiccating in the package.

Talburt, W. F., Hendel, C. E., and Legault, R. R. *Food Eng., 26,* 79-81+, April, 1954.

Discussed are: what desiccant to use, how to package it, volume it occupies in package, and precautions in using calcined lime.

What about contract packaging?

Modern Packaging, 27, 71-7+, April, 1954.

The survey discloses the broad range of contractor services available and suggests typical situations in which they may be desirable.

Screen tests for packages.

Fibre Containers, 39, 104, March, 1954.

A color testing service for advertisers who wish to screen test their product packages for color TV is offered. It will det. in advance how packages will look on the color system thus allowing time to make changes prior to TV color presentations.

SOAPS

New antiseptic for soap.

Vinson, L. J. *Soap and Sanit. Chemicals, 30,* 44-7+ April, 1954.

Tetramethylthuiram disulfide has greater practical value as a soap antiseptic than the bisphenolics currently in use. It exhibits activity against a wider spectrum of bacteria and fungi, has a greater substantivity to skin, compares favorably in mildness to pure soap and has no discoloring effect on soap.

PATENTS

Means for protecting food commodities.

Barnet, F. G. Assignor to Fulton Bag & Cotton Mills. 2,674,509, April 6, 1954.

Relates to bags adapted to contain edible commodities, particularly to the improvements in textile bags, for edible commodities which are absorbent to moisture and odors of flavors from other commodities stored nearby or in adjacent containers.

Reliability of Taste Testing and Consumer Testing Methods. I. Fatigue in Taste Testing

ELSIE A. LAUE, NORMAN H. ISHLER, AND GLORIA A. BULLMAN
Central Laboratories Division, General Foods Corporation, Hoboken, New Jersey

(Manuscript received September 14, 1953)

The effect generally known as fatigue has been discussed subjectively by many writers in the field of sensory evaluation. In organoleptic testing, it is characterized by diminishing ability of a taster to recognize small differences in flavor as tasting is prolonged. It is a common complaint among taste test panel members.

Almost all organoleptic groups, recognizing the existence of fatigue, provide conditions for tasting operations designed to minimize its effect and thus maintain panels at maximum efficiency.

A common procedure is to limit the number of samples to be tasted at any one trial. Bengtsson and Helm *(1)* attribute fatigue to reduced functioning of the gustatory and olfactory nerves. They suggest that the stronger the taste and odor, the fewer the samples tasted. For routine quality control testing, however, where materials are usually not pronounced in taste or odor, the number of samples may be increased to three or four or even more samples.

Peryam and Swartz *(8)* indicate that if samples contain flavor characteristics of low impact or intensity, one triangular test may be followed by a second, provided a short rest is taken between them. Clendenning *(2)*, in a paper on "Flavor in Confections," ascribes fatigue to exhaustion of sensory end organs when stimulation is repeated. He recommends that as few samples as possible be presented to the taster.

Crocker *(3)* says that recovery to normal sensitivity after stimulation is a matter of minutes. He suggests that tasting be slow, with rest periods of a minute to five minutes between tastes, depending on the material. He also points out the usefulness of rinses to remove any adherent material from the mouth but feels that a normal flow of saliva is best for this purpose.

The literature shows that the more objective work has been done on actual physiology of taste rather than on organoleptic testing. Some physiological investigations serve to demonstrate that fatigue or a similar phenomenon exists in some instances of food ingestion. The opposite effect, stimulation of some taste receptors, may possibly be achieved.

Janowitz and Grossman *(7)* found that previously ingested substances causing satiety had little or no effect on taste acuity where tests were run with sugar and NaCl solutions. Timofeev and Kroll-Lifshits *(9)* changed the mineral balance of dogs and found that salivary secretion decreased in some instances. Following the feeding of Na_2HPO_4, the threshold was raised for salts and lowered for acids. Ehrenberg and Güttes *(4)* claim that small amounts of KCNS have been observed to lower the threshold of some substances while raising the threshold of others.

The only truly objective attempt to measure taste fatigue which we have found in taste testing literature was reported by Helm and Trolle *(6)*, in 1946. They described the effect found in running two triangular tests in close succession. Three pairs of beer samples were tested twice in succession by the same panel. In each test, the panel consisted of 73 tasters, 37 of whom were classified as experts. It was reported that a water rinse was provided between samples but very few tasters actually took advantage of this facility.

A reduction in the percentage of successes in selecting the odd sample was reported for the second triangle of each of the 3 tests. Our χ^2 analysis of the Helm and Trolle data shows that none of the 3 individual tests involving 73 judgments resulted in a statistically significant reduction in number of successes in the second triangle. Only one of the 3 cases involving the individual group of 37 experts showed a significant reduction in number of successes. When the 3 tests are combined, however, the overall reduction in the number of successes is found significant at the 4% level. The overall reduction for the expert group is likewise found significant at 3%.

In our laboratory, triangular tests are used extensively for routine difference evaluation of coffee and other products. In order to obtain a maximum number of judgments and at the same time keep the cost of testing low, two triangular tests are presented at one sitting. Thus, over a period of panel history, we have been able to collect a fair amount of data on double triangular tests, that is, two triangular tests at one sitting.

The double triangular test as we use it is conducted under conditions we have found most conducive to taste test efficiency. These conditions include individual booths for the tasters, proper ventilation and temperature control, and regulated lighting to eliminate color differences. In addition, uniformity of sample temperature is maintained at approximately that of normal consumption of the product. The order of presentation of the samples within the 2 triangles is randomized from taster to taster. This is done so that no one sample will be in center position for all the tasters. [Harrison and Elder *(5)* reported that in cases where difference is doubtful there is a tendency for the tasters to pick the sample in the center position as the odd one.] To keep our scheme of randomization inconspicuous, code letters are marked on the back or bottom of the sample containers. Tasters are instructed to identify the samples by code, only after their choice of the odd sample has been made. The sets of code letters commonly used for the two triangles are A, B, C, and D, E, F, respectively. The code letters assigned to control and variant samples

are randomly selected, as well as the letter which is to represent the odd sample.

Spring water at room temperature and salted crackers are provided for use between tastes. No particular technique of tasting is prescribed; some tasters find it helpful to sip liquid samples, while others prefer to drink them. Some repeat tasting many times, while others rely on memory and taste each of the 3 samples only once.

During the past year and a half, we have accumulated the results of 148 double triangular tests on soluble coffee evaluated by an expert panel. In all of these, the sample pairs were the same for both triangles. In half of the tests, the odd sample of the first triangle was presented as the duplicated sample in the second triangle. In the other half, the odd sample of the first triangle remained the odd sample in the second.

These 148 sets of successive tests were compiled and tabulated into the contingencies shown in Table 1.

TABLE 1

Summary of the number of successes and failures in a series of double triangular tests on coffee

Results	First triangle	Second triangle	Both
Successes	856	880	1736
Failures	863	839	1702
Total	1719	1719	3438

It is apparent that there is no question of a lessening in sensitivity due to fatigue in this series. In fact, the total number of successes in the second set of triangles is even greater than in the first.

This increase was of sufficient interest so that the data were examined by χ^2 analysis to determine whether there might be some real cause for this apparent increase in sensitivity. However, no significance was found by this analysis, since the level of significance was found to be 45%.

Fatigue has been evaluated under similar conditions for maple syrup. This product is considered by our trained panel to be one of the most difficult to taste because of its decided sweetness.

A series of tests on blended maple syrup was conducted using double triangular tests. Samples were served in dark brown plastic cups to eliminate color difference. The codes used in both triangles were A, B, and C. No attempt was made to randomize their order of position from taster to taster. However, the position of the odd sample was randomized from test to test. The syrup was served at 13° to 15° C., the temperature presumed to offer maximum discrimination. Tap water and salted crackers were provided for use by the tasters.

Results of this series of tests are shown in Table 2.

The difference in results between the first and second triangles was examined by χ^2 analysis and found to be significant at the 2% level. This definitely suggests that

TABLE 2

Summary of the number of successes and failures in a series of double triangular tests on maple syrup

Results	First triangle	Second triangle	Both
Successes	97	75	172
Failures	70	92	162
Total	167	167	334

fatigue was operating since all other factors of variation were either randomized or controlled.

The total data thus far collected point up the need for further investigation of fatigue in product testing. Certain principles covering fatigue may eventually be derived from more extensive testing. Coffee, for example, which is far from bland, produced no fatigue. This suggests that fatigue may not be as important in the tasting of other highly flavored substances as commonly believed.

The procedure as described may also be extended to evaluate the effectiveness of commonly used precautions against fatigue, such as waiting periods, mouth rinses, etc.

SUMMARY

The familiar triangular test has been used to measure the effect of fatigue in taste testing. Series of tests were studied, in each test of which two successive sample triangles were presented to the tasters. In those cases where a significant reduction in success was noted for the second triangles, fatigue was considered to be operative.

Fatigue seems prominent in the tasting of some types of food products, while it is practically negligible in others. Helm and Trolle have found that fatigue is apparent in the tasting of beer. We have found the same to be true in the tasting of maple syrup. In coffee tasting under our conditions, fatigue did not occur.

Additional objective testing is needed to establish the importance of fatigue in the tasting of other substances.

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Reliability of Taste Testing and Consumer Testing Methods. II. Code Bias in Consumer Testing

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The food industry, each year, carries out a large number of consumer tests in an effort to help the manufacturer find out what the consumer wants. All sorts of precautions are taken to insure that the results reflect a true picture of consumer preferences. Test locations are carefully selected. Population samples are carefully stratified according to distribution of income levels, age, eating habits, family size, etc. Questionnaire wording is precisely worked out to convey exact meanings to the respondent and to extract the amount and quality of information needed.

All of the above precautions are largely matters of judgment and involve considerable thought and ingenuity on the part of the consumer researcher. Seldom, however, does anyone set up control tests to measure the effectiveness of this planning. The carefully planned test is simply accepted as the best that can be obtained for the purpose desired, under whatever existing cost limitations there may be.

Codes assigned to samples for a consumer test are similarly relegated to the realm of judgment and experience. Organizations running consumer tests use a variety of coding systems. Some use letter codes, others numbers. Some use two digit numbers, others use as many as four or five digits. Some combine numbers and letters. Some code samples by assigning a color to each; others prefer to use geometrical shapes such as circles, squares and triangles.

Literature concerning code biases which are manifested in consumer product testing seems to be practically non-existent. Communications with several consumer research and marketing agencies resulted in a diversity of opinions on the subject. One agency has explained that, to date, it has never observed or recorded any observation of the effect of letter or number designation on the respondent.

FINDINGS OF SURVEY GROUPS IN REGARD TO BIAS

However, several survey groups are keenly aware of the presence of code bias. One of these organizations *(2)* believes that 2 types of bias are introduced by code designations. First, a bias is introduced by the letters or numbers themselves, which is relatively independent of the individual or situation. For example, letters are preferred according to familiarity: E, A, T, N, are preferred to X, Q, J, and Z. With numbers this also holds true: even numbers are somewhat preferred to the odd, with 7 as the exception. Second, a bias is introduced by individual preference or situational factors. These are unpredictable items such as one's own initials, letters that suggest a brand of the product concerned, etc.

S. W. Wilkerson Associates *(4)* reported finding definite biases in the use of the letters A, B, C or X, Y, Z. In cases where housewives had indicated their first choice for products bearing such letters as M, L or S, it was found that their choice could be swayed by re-lettering the products A, B, or C. In other words, housewives would select a product they had originally rejected merely because they were prejudiced on the quality of the letters A, B, or C. This same organization felt that code numbers were not as satisfactory as code letters since people seem to prefer 1 over 2, 10 over 9, etc. For some instances they suggest using circles, squares, diamonds, etc. as code symbols.

Lester R. Frankel *(1)*, technical director of Alfred Politz Research Inc., New York, New York, recently wrote us in answer to an inquiry, "While we suspect a bias does exist due to codes used in paired comparison tests we have never made an attempt to measure this bias. The reason for this is that through the use of proper experimental design, the effects of any such biases are eliminated. For example, if Product One is being compared with Product Two, we would set up the code A = Product One, B = Product Two for one half the cases, and we would reverse the code, i.e., B = Product One, A = Product Two—for the other half." Some of the information presented in this paper is based on the use of this technique.

TWO TYPES OF TESTING

We use two main testing techniques in presenting samples to the consumer public for evaluation. To conduct one of these, called store tests, space is rented at various department stores in the New York City area. Code letters are assigned to the sample pairs. Participants are requested to taste both samples side by side and express their preference. Half the respondents taste one sample first, half taste the other first. All answers and comments are given verbally to the interviewer who records the information. No publicity or product advertising is allowed in conjunction with these tests.

Home use tests, the second of our 2 techniques, are in common commercial use. They are conducted for us by consumer research groups and are run most frequently in the metropolitan New York area. Trained interviewers call on housewives personally to enlist their cooperation. Housewives are requested to prepare the samples according to directions on the jar or box label. Code letters, and occasionally code numbers, are assigned to the samples being evaluated. In all home use tests, questionnaires are used which the respondents are requested to complete. After approximately a 3-day period, interviewers collect these questionnaires and submit them to the agency for tabulation.

Many pairs of coffee samples have been tested by both store tests and home use tests. Among these, several cases have been observed in which the 2 types of tests failed to agree within limits which might be expected by chance variation. Code bias was among the factors considered as a possible cause of this lack of agreement.

Special store tests were set up to try to determine how serious a problem code bias might be. Normally, a participant in a store test, as we run these tests, may not even be aware that codes are used. Two portions of a food are placed before him, and in many cases the coding on the container is observed only by the interviewer. The participant may answer by saying "I like this one better," holding up the container or pointing to it. Thus sample codes are unlikely to influence the respondent's decision.

MEASURING BIAS

To *measure* bias, therefore, codes were deliberately made particularly prominent. The combinations of code symbols selected for the testing were representative of those used most frequently by consumer research agencies in setting up home use tests.

Each participant was given a simple card ballot on which space was provided to check the code symbol representing his preference, or to express lack of preference. Space for comments or reasons for choice was also available. The use of a ballot forced the consumer to think of the samples in terms of their codes. For these particular tests, the 2 samples served were identical. Soluble coffee was chosen as the testing material. To

reduce chance difference to a minimum, the beverages were prepared a liter at a time with weighed portions of coffee and carefully measured quantities of water. Separate pots of beverage were prepared and coded the same way as the cups so that the respondent had no clue to the fact that the samples were identical.

The results of these tests are shown in Table 1.

TABLE 1

More favored code	Less favored code	Preference ratio	No. judgments
U	T	1.35:1.0	200
L	M	1.30:1.0	200
L	F	1.30:1.0	200
Q	F	1.23:1.0	200
J	C	1.20:1.0	200
Q	K	1.20:1.0	200
26	23	1.20:1.0	200
L	O	1.10:1.0	200
B	L	1.05:1.0	200
K	L	1.03:1.0	200

Results show greater symbol preference in code pairs at the top of the list. Symbol preference in pairs at the bottom of the list is almost negligible. Although none of the preference ratios is significant at the 5% level for 200 judgments, the magnitude of all but the last three is such that it would constitute a serious error if true preferences for samples were influenced to this extent. Thus, a sample for which there is a slight preference will appear to be much more preferred if the code letter representing it is one for which there is a high preference. Conversely, a sample for which there is a marked preference will appear to be much less preferred if the code letter representing it is one for which the preference is low.

A practical attempt was made to measure code letter bias in routine store tests on soluble coffee, consisting of 300 judgments each. The practice of reversing code letters for test halves was employed. That is, in one half of the test, or approximately 150 judgments, the codes were reversed from those in the other half, or second 150 judgments. Colors of jar labels were different for the two halves to avoid confusion and error in tabulating results. Thus, white D and R samples were identical with respective yellow R and D samples. To tabulate results of such a test, preferences pertaining to white D and yellow R were combined and similarly, those pertaining to white R and yellow D were combined. This, obviously, tended to cancel out any bias due to code preference.

For our purpose of measuring code bias however, the preference for white D and yellow D were combined as were preferences for white R and yellow R. This cancelled out valid preferences for samples, since both were represented in equal numbers. Any residual preference may therefore be ascribed to random variation or to code bias.

Statistics, or just plain experience, will tell us that random variation in a test of 100 to 1,000 judgments may be fairly great. Code biases determined as described above should be based on a fairly large number of judgments, using several different pairs of samples. By using large numbers, other effects which by chance might coincide with code bias would thus have a fair opportunity to be randomized.

A compilation of results from over 500 store tests in which codes were reversed for every half test showed biases as listed in Table 2.

The individual tests amounted to approximately 300 judgments on a particular sample pair. Thus, any possible interaction between sample and code designation was fairly well randomized.

TABLE 2

More favored code	Less favored code	Preference ratio	No. judgments
W	E	1.07:1.0	3,800
K	L	1.06:1.0	21,000
T	U	1.02:1.0	6,000
D	R	1.02:1.0	120,000

No bias, at least not one of any considerable amount, is apparent in the 4 letter pairs above. Since the ratios are based on a relatively large number of judgments, it is safe to assume that code letter bias in store tests is almost nil.

Home use consumer tests, on the other hand, seem ideally subject to influence from codes. This is due to the fact that in a home use test, the respondent is forced to identify each sample with its code, other identification normally being unavailable.

Also, it is easy to picture that in the home test a respondent may fail to record a preference on the questionnaire immediately after a decision has been reached. Thus he may have to rely on his memory of the preferred sample, as represented by a code alone, when at some later time the interviewer returns to collect the questionnaire. Under these conditions, a code designation may be a relatively important memory factor.

Since home use tests are too expensive to permit running tests on identical samples merely to study code bias, an attempt similar to that described above was made to measure code bias from routine tests. The practice of reversing codes for test halves was again employed. Table 3 summarizes the results found from the compilation of over fifty home use tests. Each test consisted of approximately 300 judgments on a particular sample pair.

TABLE 3

More favored code	Less favored code	Preference ratio	No. judgments
K	L	1.30:1.0	4,768
E	W	1.23:1.0	3,682
U	T	1.08:1.0	2,677
D	R	1.01:1.0	4,308

The first two of these 4 code letter pairs indicate a tendency toward more bias than the two remaining pairs. Their corresponding preference ratios are statistically highly significant. All the preference ratios found above however, do not coincide with those of Table 1. This may be due to the fact that the data of Table 1 are based on 200 judgments per code pair while those of Table 3 are based on much larger numbers. On the basis of larger numbers alone, the latter should be considered more reliable. It may be however, that there are other bias factors involved in the home use test which were not measurable in the store tests on identical samples. Thus, the data of Table 3 clearly indicate that a code bias does exist in routine home use tests where there is opportunity for strong mental associations of code with the sample it represents.

MINIMIZING BIAS

It is apparent that this bias can be minimized in either of two ways: (a) by reversing codes between halves of each test to cancel out the bias, or (b) by using only codes for which no appreciable bias has been found. The former procedure is probably the safer of the two, since codes which show no bias in one sample of the population, may be found to possess a bias in another population sample.

It should be noted that even when bias is cancelled by reversing codes, a damping effect may remain which will tend to lessen the sensitivity of a test. This results from the fact that respondents whose choices are based on code preference, obviously contribute nothing to determining a preference for the samples. As a result, the magnitude of the preference for a more favored sample may be somewhat "watered down" by these non-contributing respondents.

A method for correcting this damping tendency has been described in an unpublished report by Harrison *(3)* of Kraft Foods Company Research Laboratories. Harrison's procedure depends on a previous knowledge of the bias existing for the particular code designations used. Apparently, however, the procedure suggested could not take into account the expected variation in influence of code bias depending on the intensity of preference which may exist for the samples being tested.

SUMMARY

It has been demonstrated that bias effect from codes can be conveniently minimized by selecting code pairs

which have been demonstrated to show little bias and by reversing codes between test halves. This reversing procedure tends to equalize code biases so that they no longer operate in favor of one sample at the expense of the other.

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Variation in Determinations of Shear Force by Means of the "Bratzler-Warner Shear"[a]

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The investigation of variation in shear force measurements by means of the Warner-Bratzler Shear was made using parowax and beeswax as homogeneous standards to display a minimum of variation in the test material. The variation observed in the experimental results could be thus ascribed primarily to the apparatus used for testing. Three criteria of tenderness were investigated for use in connection with the Warner-Bratzler apparatus: (1) maximum shear force (commonly used at the present time), (2) total time necessary for failure in shear and (3) the slope of the shear force vs. time curve. This last criterion was found to be best as it displayed the smallest coefficient of variation and highest discriminative ability between treatments which were in fact different.

Objective evaluation of tenderness of meat by generally accepted practice in food research is expressed in terms of maximum shear force obtained by means of Bratzler-Warner Shear apparatus. Such determinations display very wide variations. Ramsbottom and Strandine *(2)*, Bard and Tischer *(1)*, and Tischer, Hurwicz and Zoellner have demonstrated the occurrence of extreme experimental variations in the determination of shear force in beef subjected to various processing conditions.

Similar difficulties are encountered in the evaluation of thermal and other physical characteristics of beef because of large variations in individual determinations. The variation of the means, however, is considerably smaller when a sufficient number of determinations is available and the mean experimental values lend themselves to a mathematical treatment resulting in rather well behaved functional relationships.

In shear force determinations, extremely large variations persisted in means of eight to ten determinations per sample and through several replicates *(3)*. The relationship of shear force to processing time discussed in *(3)* displayed characteristics of a roughly sigmoid curve and did not lend itself easily to mathematical interpretation. Only approximate prediction equations could be derived because of the large variations in the measurements.

Either an inherent variation of the shear force apparatus, or of the criterion of the maximum shear force itself as determined by Bratzler-Warner Shear may be responsible to a great extent for the experimental variations encountered in attempts at objective evaluation of the tenderness of meat.

The determination of either the error of the machine (its calibration) or the development of a new criterion of tenderness would allow an improved and more critical interpretation of the results of shear tests on meat and facilitate a separation of the errors due to the lack of homogeneity of meat from those inherent in the apparatus. An improvement of the design of the apparatus could be made to eliminate its lack of precision or perhaps the development of a new criterion of tenderness would result in experimental values with smaller experimental error. If the new criterion (such as the slope of the shear force vs. time curve) displayed smaller variation, the present Bratzler-Warner apparatus could be retained without modification to yield more precise results than those afforded by the maximum shear force criterion used at the present time.

In view of these considerations the Bratzler-Warner shear apparatus was tested to evaluate three criteria of tenderness:

a. Maximum shear force
b. Total time for failure in shear
c. Slope of the shear force vs. time curve.

To avoid the bias and variability attached to the material tested, waxes were chosen as testing standards because of their chemical homogeneity. It was assumed that variation displayed while testing waxes could be ascribed primarily to the Bratzler-Warner apparatus. The experimental errors determined in this manner could then be attributed to the measurements performed by the apparatus and separated from the variations observed in testing other materials. In effect, the shear force apparatus would be calibrated.

The assumption of the homogeneity of waxes chosen as the standards for calibration may be justified as relative to a definite lack of homogeneity of biological ma-

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terials such as meat and by the fact that they were used by Bratzler *(4)* in designing the apparatus.

This experiment was undertaken to determine the magnitude of variations associated with "Bratzler-Warner Shear" and to compare the three proposed criteria of tenderness.

EXPERIMENTAL PROCEDURE

Parowax and beeswax were chosen as standard materials in testing the variability of the machine. Other waxes originally considered were found to be too hard and too brittle, and their shear strength did not fall in the range occupied by beef.

The shear force tests were made for these *2* waxes at 4 temperatures (*32, 45, 60,* and 80° F.) to obtain a varying range of hardness represented by varying melting points and to demonstrate whether the machine would yield results correspondingly dependent in terms of variance (or experimental error) on the hardness of the sample.

A *2* x 4 factorial design in completely randomized blocks was used (4 reps). One half inch diameter cylinders of wax were cut with a cork borer, brought up to the required temperature, and tested immediately upon removal from conditions of controlled temperature.

A moving picture was made of every test using a camera mounted above the apparatus to record the movement of the scale hand on the dial and the passage of time as recorded on an electric timer installed close to the dial. The film was projected using a still projector and the data (shear force values and time) were transcribed and tabulated frame by frame. In this manner shear force values were obtained at approximately one-second intervals throughout the duration of the total shearing process.

RESULTS AND DISCUSSION

Parowax and beeswax appeared to substantiate the assumption of their homogeneity, as they showed no evidence of fractures and other damage during handling; no cleavage surfaces were apparent in the sample cylinders cut out with the cork borer.

The transcribed shear force data were plotted against time for each determination, and the maximum shear force attained and total time necessary for failure were recorded. The slopes of the curves were determined by linear regression since the plot of shear force vs. time suggested linearity. An analysis of variance of the 3 criteria considered (Table 1) indicated largest variation

TABLE 1
Partial analysis of variance for three criteria of tenderness

		Max.shear force		Total time		Slope	
Source	*df*	*M.S.*	*"F"*	*M.S.*	*"F"*	*M.S.*	*"F"*
Among Treatments	7	48.58	.....	4.025	.....	0.3058	.....
Waxes	1	44.18	29.26[1]	0.3628	0.67	0.4351	60.43[1]
Temperatures	3	96.03	63.60[1]	8.5287	14.95[1]	0.5658	78.58[1]
W X T	3	2.60	1.72	0.7370	1.29	0.0028	0.38
Units Treated Alike	24	1.51	.....	0.5703	.....	0.0072	.....

[1] Significant at 1% probability level.

for the maximum shear force and smallest for the slope of the shear force vs. time curve. The variation of the total time criterion was intermediate in magnitude. Small variance of measurements of slope may be explained by the large number of observations necessary for its determination while the other *2* criteria are determined from one observation only. Also the smaller order of magnitude of the slope compared to the other criteria may be responsible for the small variance.

In view of these occurrences, small variance in the slope determinations may be considered as evidence that the slope is the best criterion of tenderness only if the coefficient of variation (C.V. = Standard deviation/mean) of the slope is smaller than for the other *2* criteria. A high capacity for distinguishing among groups actually different should also be an attribute of the criterion considered best.

Table *2* was set up to evaluate the merits of each of the 3 criteria and shows the coefficients of variation (C.V.) associated with the measurement of each of the characteristics. The Chi-square values for 4 temperatures resulting from Bartlett's test of homogeneity of variance indicated that the variances were homogeneous and thus could be pooled to facilitate the comparison of the 3 criteria presented in Table *2*. Slope showed the smallest C. V. for the pooled data of both waxes and all temperatures and therefore may be considered as the best criterion. A plot of the C. V. and s (Figure 1) for

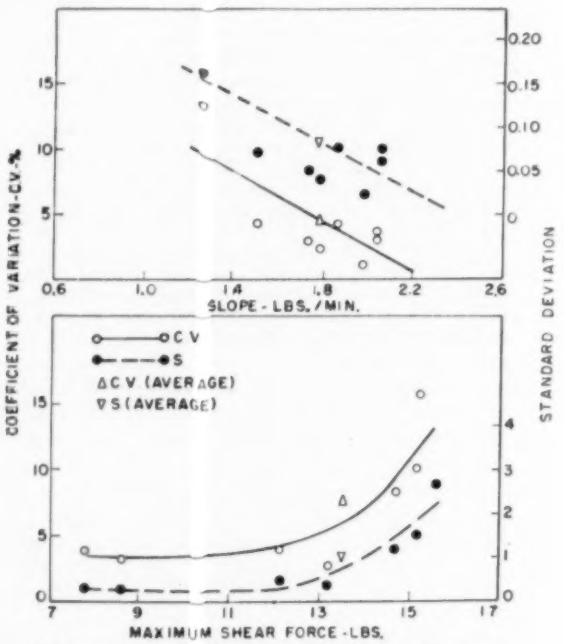

Figure 1. Variation of two criteria of tenderness.

the average of 4 determinations of each characteristic is in effect a calibration curve of the "Bratzler-Warner Shear" for each of the 3 criteria tested, which could be used in further tests of tenderness of meat. Figure 1 indicates also that the standard deviation s and coefficient of variation (C. V.) for the slope determination decrease with the increase in absolute value of the slope. This occurrence is desirable since the actual slope values for beef are found in the range where both s and C. V. are small. The opposite phenomenon is observed for the maximum shear force standard deviation and coefficient of variation. No definite trend was observed for the same statistics of total time necessary for failure. This evidence also supports the contention that slope is the best criterion of tenderness.

The ability to distinguish among treatments which are in fact different was tested by the "F"-test which indicates, by the values associated with waxes and tem-

TABLE 2

Variations and mean values of three criteria of tenderness for beeswax and parowax

Temp. (° F.)	Parowax				Beeswax			
	Average	$(s^2 \times 10^3)^1$	$(s \times 10^3)^2$	C. V. (%)[3]	Average	$s^2 \times 10^3$	$s \times 10^3$	C. V. (%)
Slope of the Shear Force vs. Time Curves (lbs./min.)								
32	2.0310	4.108	63.25	3.11	1.0536	6.010	77.45	4.18
45	2.0318	5.619	3.58	3.58	1.7817	1.602	40.00	2.24
60	1.9803	5.185	22.76	1.15	1.7284	2.573	50.99	2.95
80	1.5009	3.965	62.44	4.16	1.2475	28.301	168.22	13.48
Pooled	1.8860	4.719	68.55	3.63	1.6528	9.622	97.98	5.93
Maximum Shear Force (lbs.)								
32	17.92	442.5	663.3	3.70	14.70	1460.0	1208.3	8.22
45	15.62	7282.5	2698.0	17.27	13.23	129.2	360.5	2.73
60	15.17	2349.2	1532.0	10.10	12.13	209.2	455.2	3.78
80	8.60	80.0	282.8	3.29	7.83	89.2	298.7	3.82
Pooled	14.33	2838.6	1593.7	11.12	11.97	471.9	685.5	5.73
Total Time for Failure (secs.)								
32	9.87	229.2	479.3	4.86	6.87	229.2	479.5	5.40
45	8.37	1729.2	1315.2	15.70	8.76	260.0	500.0	5.71
60	8.62	1062.5	1029.6	11.94	6.78	416.7	647.9	7.40
80	7.12	229.2	479.5	6.73	6.75	415.7	647.9	9.80
Pooled	8.50	812.5	900.1	10.59	6.28	328.2	574.3	6.93

Pooled means for both waxes

	Mean	$s^2 \times 10^3$	$s \times 10^3$	C. V. (%)
Slope	1.7694	7.175	84.80	4.79
Max. Sh. F.	13.50	1005.00	1002.0	7.41
Total time	8.39	570.35	754.9	9.00

[1] Variance. [2] Standard deviation. [3] Coefficient of variation.

peratures, that the total time criterion has the least capacity to distinguish (Table 1). The slope and maximum shear force both have high ability of distinguishing. The slope seems to be the better criterion because of the highest "F"-values resulting from the tests.

The highest ability to distinguish among different treatments connected with the lowest coefficient of variation substantiate the contention that slope is the best criterion to be used in connection with determination of tenderness by means of "Bratzler-Warner Shear."

Further evidence in favor of the slope as the "best" criterion of tenderness is given in Table 3 in which are data on the coefficients of variation for 21 mixtures of parowax and beeswax tested at room temperature. The average coefficient of variation for the slope was 2.71% as compared with 22.89% for the total time and 24.13% for the maximum shear force.

TABLE 3

Mean values and variation of the three criteria of tenderness for 21 mixtures of parowax and beeswax

% beeswax in parowax	Criterion: Slope lb./sec.	C. V.	Total time: Sec.	Total time: C. V.	Max. shear force: lb.	Max. shear force: C. V.
0	1.53	2.69	6.2	17.22	11.2	22.30
5	1.63	2.81	7.3	19.80	13.2	26.24
10	1.54	2.68	7.9	19.89	13.5	24.58
15	1.63	2.67	8.3	24.34	14.0	25.75
20	1.49	2.85	8.5	22.35	13.9	22.36
25	1.44	2.70	9.0	26.43	13.6	24.39
30	1.50	2.91	8.5	26.83	14.0	26.73
35	1.46	2.82	9.0	22.33	12.7	22.30
40	1.43	2.62	8.5	26.43	12.3	24.47
45	1.37	2.31	8.5	24.45	12.0	24.55
50	1.33	2.81	8.3	24.34	12.0	24.45
55	1.28	2.71	8.4	22.27	11.7	24.55
60	1.32	2.40	7.3	24.58	11.0	22.40
65	1.38	2.61	7.0	22.32	11.1	22.27
70	1.43	2.60	7.0	22.32	10.6	26.57
75	1.51	2.65	6.3	24.59	10.4	24.57
80	1.42	2.82	7.1	24.35	10.3	22.31
85	1.50	2.67	6.5	22.35	10.6	24.38
90	1.61	2.64	6.8	19.83	11.3	22.41
95	1.57	2.85	6.9	19.87	11.1	24.49
100	1.69	2.84	6.8	24.30	11.7	24.56
Average	1.48	2.71	7.6	22.89	12.0	24.13

CONCLUSIONS

The maximum shear force as used at the present time as the criterion of tenderness by means of Bratzler-Warner shear displayed a pooled C. V. = 7.41% and is not the best criterion of tenderness to be used in connection with this machine.

The shear machine should be redesigned in an attempt to lower the experimental error inherent to it (shown in Figure 1 for the average of four determinations). This experimental error may be ascribed, on the assumption of homogeneity of the standard tested (waxes), to the machine only.

The slope of the shear force vs. time curve has been found to be the best criterion of tenderness with "Bratzler-Warner Shear" because of the smallest pooled C. V. = 4.79% and because of its ability to distinguish among treatments which are in fact different.

These conclusions were substantiated by experiment with mixtures of beeswax and parowax.

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Temperature of Popper in Relation to Volumetric Expansion of Popcorn

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Four popcorn hybrids were used to determine the relationship between temperature of the popper and the popping expansions of the corn. It is shown that there is much to be gained by preheating the popper to temperatures higher than 470° F. (243.3° C.). A temperature of 550° F. (287.8° C.) appears to be optimal.

Maximum popping expansion may be obtained only when the temperature of the popper is in proper relation to the moisture of the sample. Stewart *(3)* recognized the importance of this relationship, but since he had no means of measuring temperatures he noted that 80 g. samples had an optimum popping time of 125 seconds. Below 105 and above 165 seconds there was usually a drop in expansion. In addition he found that popping time increases in relation to moisture content of the sample and to its weight. Carr and Ripley *(1)*, who used lard as a popping compound, state that with a 30 ml. sample popping started at 340° F. (171.1° C.) and became rapid at 380° F. (193.3° C.), the best expansions being obtained when the popping was completed in 150 to 180 seconds. Eldredge *(2)*, who used the official volume tester which is the same type available for the experiments to be discussed subsequently, states that with a 3 oz. measure the optimum expansion is obtained by dumping in the seasoning at 460° F. (237.8° C.) followed by the corn preheated to room temperature. Under these conditions popping starts in 60 seconds and is completed in a total elapsed time of 110 to 115 seconds. Since the economic value of any given lot of popcorn is conditioned by its popping expansion, it follows that no factor affecting volume should be overlooked. The few and somewhat confusing references concerning the factors governing the conditions under which corn should be popped indicate the need for more detailed information.

MATERIALS AND METHODS

The so-called "Official Volume Tester" * is the one generally accepted by the trade. Although called "official," it has not been approved by any government agency and there are no official standards specifically for popcorn. The tester consists of an electrically heated covered pan provided with a motor driven stirrer. The pan is attached to a large square funnel and hinged so that the popped corn may be dumped. A cylinder attached to the bottom of the funnel is provided with perforated numbered slots. The equipment consists of 3 and 6 oz. cups for measuring the popcorn and a 2 oz. cup for measuring the oil, or seasoning. The 6 oz. cup fills the 4 in. measuring cylinder 1 in. deep. The usual tester measures from 13 to 33 inches or volumes, but the one used in these experiments measures up to 40 inches or volumes. The manufacturer suggests popping samples in triplicate, but with care it was found that duplicate poppings were sufficient, and all the volumes reported here are the averages of duplicate samples at least.

* Manufactured by C. Cretors and Co., Chicago, Illinois.

The tester is rated to operate on a load of 1100 watts at 115 volts. The instructions call for pouring in the liquid seasoning and then heating the popper until the pyrometer reads 470° F. (243.3° C.) at which temperature the previously measured sample of popcorn is dumped. The sample should be at room temperature. This type of popping is called "wet popping" which gives different results from dry popping without added oil. Coconut oil measured out in a glass graduate rather than in the crude cup furnished with the tester was used in all the experiments reported here. In addition only the 6 oz. cup was used to measure the popcorn. These details are given as even slight variations are capable of changing the volumetric relations.

The hybrids Purdue 32 and 202 and Iopop 5 and 6 rehydrated with water to the indicated moisture percentages were used in these experiments. All lots had been dried by artificial heat. The samples actually popped were weighed out. Merely measuring the samples will give variations up to 7 g. per 6 oz. cup depending upon the care used. Using the same technic in all the experiments 5 replicates of each sample were poured into the cup, weighed and then averaged. This average was the weight of the sample actually popped. All the temperatures subsequently discussed were read from a Wheelco Model 192 pyrometer and the time was recorded with an accurate stop watch.

Since the experiments deal with time-temperature relationships in popping corn having variable moisture contents, comparisons would be difficult to make unless the tester heats at a uniform rate until actual popping is well under way. The two regressions in Figure 1 are typical of the heating rate of the

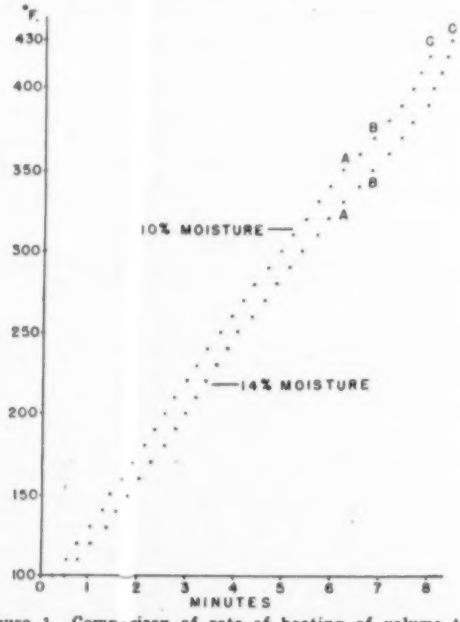

Figure 1. Comparison of rate of heating of volume tester loaded with coconut oil and two samples of Purdue 202 at 80° F. (26.6° C.) and timed from 90° F. (32.2° C.), one run with a sample containing 10% moisture and weighing 199 g. and a second run of the same lot rehydrated to 14% moisture and weighing 192 g. Points A, B and C on the curves are respectively the start of popping, rapid popping and completion of popping.

tester used in these experiments. There is an initial difference of 13 seconds in the heating rate of the two regressions which represents the time required to heat from 90 to 100° F. (32.2 to 37.8° C.), but it should be noted that this difference is maintained and that the two regressions are distinctly linear.

EXPERIMENTAL RESULTS

As Stewart *(3)* indicated that preheating the popper offered no advantages the 1952 experiments (Tables 1 and *2*) were designed to include controls consisting of adding the seasoning and

TABLE 1

Effect of preheating popper on the expansion of Iopop 5 at three moisture levels (1952)

Kernel moisture when popped	Popper pre-heated to	Temperature drops to	Popping starts	From dumping corn to start of popping	Actual popping period	Total time required	Popping expansion
%	°F.	°F.	°F.	Sec.	Sec.	Sec.	Vols.
8.25	80	—	380	492	63	555	15.0
	370	283	378	182	58	240	18.0
	420	328	385	118	48	166	20.0
	470	350	390	95	43	138	21.0
	520	380	398	66	41	107	22.0
	570	404	406	47	35	82	22.0
11.35	80	—	358	451	90	541	22.0
	370	285	365	158	71	229	24.5
	420	312	370	110	68	178	27.0
	470	344	376	82	61	143	28.5
	520	370	382	62	57	119	29.5
	570	399	399	44	48	92	31.0
12.95	80	—	348	455	111	566	23.5
	370	276	350	147	98	245	27.0
	420	312	356	97	83	180	29.5
	470	340	365	76	71	147	30.0
	520	365	375	59	65	124	31.5
	570	390	390	44	60	104	32.5

TABLE 2

Effect of preheating popper on the expansion of Iopop 6 at different moisture levels (1952)

Kernel moisture when popped	Popper pre-heated to	Temperature drops to	Popping starts	From dumping corn to start of popping	Actual popping period	Total time required	Popping expansion
%	°F.	°F.	°F.	Sec.	Sec.	Sec.	Vols.
9.60	80	—	362	462	73	535	23.5
	370	282	369	165	60	225	26.0
	420	320	373	110	55	165	28.0
	470	342	378	89	51	140	30.0
	520	370	386	70	44	114	31.0
	570	396	398	48	43	91	31.5
11.65	80	—	358	443	82	525	29.0
	370	280	361	160	71	231	32.5
	420	315	362	105	67	172	35.0
	470	340	361	85	59	144	37.0
	520	362	380	69	55	124	37.0
	570	394	398	50	45	95	38.0
12.60	80	—	348	455	92	547	30.0
	370	280	352	146	84	230	34.0
	420	314	360	100	69	169	37.0
	470	340	362	75	68	143	37.0
	520	368	376	59	60	119	38.0
	570	395	395	43	54	97	36.5

popcorn to the unheated popper, all three being at 80° F. (26.7° C.), before the electric current was turned on. In the other runs the popper was allowed to cool down. The seasoning was then added and the popper heated to the temperature shown in column *2* of Tables 1 and *2* before charging it with the popcorn. The 570° F. (298.9° C.) temperature is the highest one for practical use as above that the seasoning started to smoke excessively.

Preheating the popper had a marked effect on the expansion even when the corn was too dry for optimum results (Tables 1 and *2*). Temperatures above the recommended 470° F. (243.3° C.) gave increased expansions in Iopop 6 and even in poorly popping Iopop 5. The results with Purdue *32* were similar, but the data are not presented. Increasing the preheat temperature shortened the time from dumping the corn to the start of popping as well as the length of the actual popping period. The corn started to pop between a low of 348° F. (175.6° C.) and a high of 406° F. (207.8° C.) which agrees well with the 340-380° F. (171.1-193.3° C.) range reported by Carr and Ripley *(1)*.

The preliminary work in Tables 1 and *2* indicated that the relationships are quite complex and in planning the 1953 work as many factors as possible were considered. Thus from Table *3*

TABLE 3

Relation between maturity, kernel moisture when popped, preheat temperatures of popper and popping expansions of two hybrids

Kernel moistures		Hybrid	Preheat temperatures of popper				
At harvest	When popped		370° F.	420° F.	470° F.	520° F.	570° F.
%	%		Vols.	Vols.	Vols.	Vols.	Vols.
29.65	10.75	Purdue 202	28.0	31.0	30.5	32.0	31.5
	11.40		28.0	31.0	33.0	33.0	32.5
	12.30		29.5	31.0	32.5	33.0	32.5
	13.40		29.5	32.0	32.5	33.0	32.5
	14.40		29.5	31.0	32.0	33.0	32.5
14.70	10.20	Purdue 202	29.0	31.5	33.0	33.0	33.0
	11.35		31.0	34.0	34.5	36.5	34.5
	12.20		32.0	36.0	35.5	37.0	34.5
	13.20		32.0	35.5	38.0	36.5	35.0
	14.45		32.5	34.5	35.5	36.0	34.5
31.00	10.20	Iopop 6	24.0	27.0	29.0	30.0	31.0
	11.15		25.0	28.5	31.0	31.0	31.0
	12.10		24.5	29.0	30.5	32.0	32.0
	13.45		25.0	30.0	30.5	31.5	32.0
	14.60		25.0	29.0	29.5	31.0	31.0
15.65	10.05	Iopop 6	26.5	30.0	31.0	—	31.0
	11.10		27.0	31.0	32.0	33.0	33.0
	12.20		28.0	32.5	34.0	34.5	34.5
	13.25		29.5	32.5	33.5	35.0	35.5
	14.15		28.5	31.5	33.5	35.0	35.5

it is evident that increasing the moisture content also increased the popping expansion. This would be expected from the work of Stewart *(3)* and others, but the response to increasing moistures differs with respect to maturity at harvest and popping temperatures. The curves in Figure *2* show the relationships more clearly than Table 3. Thus Iopop 6 harvested at 15.65% moisture gave higher popping expansions than the lot harvested at 31% moisture. Both lots responded to increasing preheat temperatures, but with the lowest popping moisture (10.12%) the lot harvested when immature gave increasing volumes up to 570° F. (298.9° C.). In contrast the more mature lot reached 31 volumes at 470° F. (243.3° C.) and failed to give further increases at 520 and 570° F. (271.1 and 298.9° C.). The same relationship holds for Purdue 202 (Table 3).

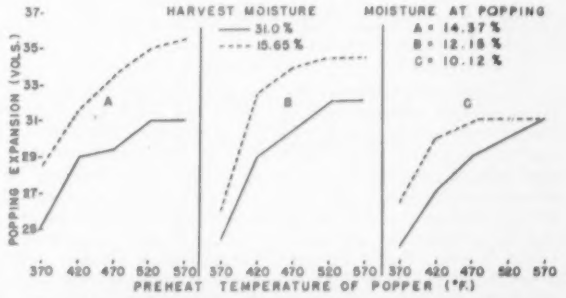

Figure 2. Relation between popping expansion, moisture at harvest, moisture at popping and preheat temperature of popper for Iopop 6 (from Table 3).

There is also a relationship between maturity of the hybrids, moisture when popped, preheat temperature, and time required for popping. Part of the data in Table 4 are charted in Figure 3. Increasing the preheat temperature reduced the time required for popping. Immature corn required more time than mature

TABLE 4
Relation between maturity, kernel moisture when popped, preheat temperatures of popper and popping time of two hybrids

Kernel moistures		Hybrid	Preheat temperatures of popper				
At harvest	When popped		370° F.	420° F.	470° F.	520° F.	570° F.
%	%		Sec.	Sec.	Sec.	Sec.	Sec.
29.65	10.75	Purdue 202	90	77	75	65	61
	11.40		95	79	70	65	55
	12.30		93	84	80	68	63
	13.40		107	88	84	71	73
	14.40		116	96	85	78	75
14.70	10.20	Purdue 202	80	72	68	58	57
	11.35		89	73	64	55	56
	12.20		81	69	71	56	65
	13.20		90	75	68	63	72
	14.45		104	86	76	69	72
31.00	10.20	Iopop 6	94	73	69	57	57
	11.15		103	75	69	63	57
	12.10		103	89	77	75	64
	13.45		108	89	85	78	71
	14.60		114	99	92	81	77
15.65	10.05	Iopop 6	76	65	58	56	56
	11.10		82	73	64	58	57
	12.20		86	72	65	61	55
	13.25		89	81	77	64	59
	14.15		105	81	73	71	68

corn and reducing the moisture content at popping likewise reduced the required popping time. Both Iopop 6 and Purdue 202 reacted in the same manner. Comparison of Figures 2 and 3 show the obviously inverse relationship between popping expansion and time required to pop which raises the question as to cause and effect. The answer seems to be that higher initial temperatures caused more rapid popping which in turn led to higher popping volumes.

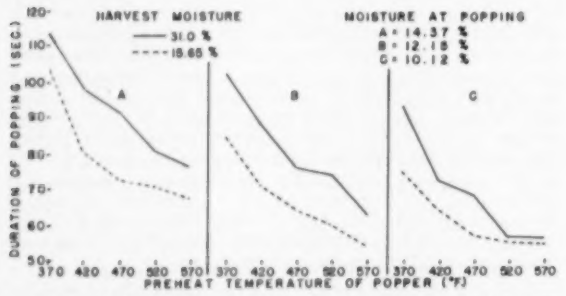

Figure 3. Relation between moisture at harvest, moisture at popping, preheat temperature of popper and duration of active popping for Iopop 6 (from Table 4).

The 1952 data (Tables 1 and 2) show that popping actually starts between 348 and 406° F. (175.6 and 207.8° C.). These temperatures should not be confused with the preheat temperatures of the popper. When the popcorn held at room temperature was dumped into the preheated popper there was a drop in popper temperature as shown in column 3 of Tables 1 and 2. This was followed by reheating and then popping. At the higher preheat temperatures the actual temperature drop was greater, but at the same time it remained within the best popping range which accounts for the fact that popping started much sooner as shown in column 5 of Tables 1 and 2.

The 1953 data have been averaged and the relationship between the moisture of the corn when popped, the preheat temperature and the temperature when popping actually starts is indicated in Figure 4. Popping started at an extreme temperature range of 343 and 388° F. (172.8 and 197.8° C.) which was almost identical with the range mentioned by Carr and Ripley (1). This range is governed by two factors, however; namely the moisture of the corn and the preheat temperature. Thus at 570° F. (298.9° C.) preheat the range of popping temperatures was 8° F. (4.5° C.), namely 380 to 388° F. (193.3 to 197.8° C.), but at 370° F. (187.8° C.) preheat the range was 17° F. (9.4° C.). Irrespective of the preheat temperature, the temperature at which popping begins decreased as the moisture content increased.

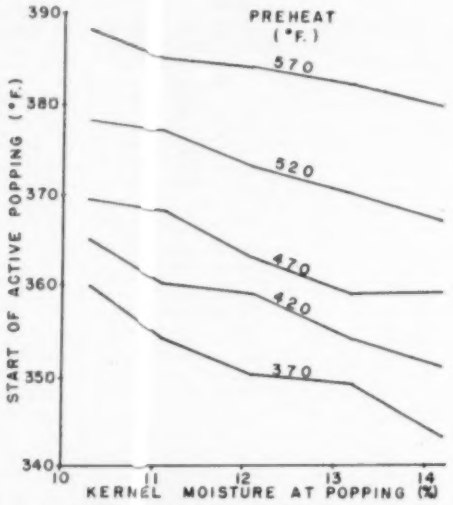

Figure 4. Relation between preheat temperature of popper, moisture when popped and the temperature when popping actually starts, combined averages of Iopop 6 and Purdue 202.

SUMMARY AND CONCLUSIONS

The official volume test for popcorn consists of adding the seasoning and preheating the popper to 470° F. (243.3° C.) before adding the corn previously brought to room temperature. All four hybrids used in the experiments gave increased expansions when the tester was preheated to temperatures above 470° F. (243.3° C.), but not higher than 570° F. (298.9° C.). The popping expansions of mature lots were more favorable than those of immature lots, but the latter gave the largest increases in expansion by increasing the preheat temperature when the moisture content was below optimum for popping. The average temperature at which popping started ranged from 343° F. (172.8° C.) to 388° F. (197.8° C.) in 1953, but the range in 1952 was somewhat greater. These differences are accounted for primarily by the moisture content of the corn; a high moisture sample begins to pop at a lower temperature than a low moisture sample.

Increasing the preheat temperature shortened the elapsed time between dumping the corn and the start of popping as well as reducing the actual popping time. Increasing moisture content of the corn is associated with increased popping time. Corn harvested when immature required more time to pop than mature corn. There was also an inverse relationship between popping time and popping expansion. Lots which popped quickly tended to have the greatest expansion.

From the practical standpoint there is much to be gained by preheating the popper to temperatures higher than 470° F. (243.3° C.), about 550° F. (287.8° C.) being suggested. Any experienced operator can predict whether a sample will pop well simply by the sound. Lots having high expansions start popping abruptly and end the same way, the explosions coming with machine gun regularity. This accounts for the fact that high volumes are inversely related to short popping periods. Since popping time is reduced by raising the preheat temperature, it follows that many substandard lots of popcorn may be readily improved.

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Microwave Irradiation of Orange Juice Concentrate for Enzyme Inactivation[a]

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Pectin-methylesterase in orange juice concentrate was inactivated in a microwave applicator using a counterflow system for exposing the concentrate to radiation from a helical director. The design of the apparatus is such that the product is heated quickly for inactivation of the enzyme and then cooled quickly to avoid side effects from the heat. The cost of operating the applicator has been estimated to be about 1.2% of the total yearly product value of concentrate produced at a rate of 13,200 cans (6-ounce) per hour per line, in a plant operating two lines simultaneously on a 24-hour basis for a total operating time of 3600 hours.

Low temperature evaporation of orange juice in the frozen concentrate industry does not expose the juice to temperatures high enough to inactivate enzymes that catalyze the breakdown of pectin, the result of which breakdown is the destabilizing of the juice. Separation of liquid and solids and gelation may result to a greater or lesser degree in the product, depending on the care taken in selection of fruit variety, method of extraction, and handling and storage of the concentrate. These considerations have been evaluated by Dubois and Kew *(1)*, and others.

The activity of pectin-methylesterase (PM) in raw juice has been found to be a measure of the tendency for the product to undergo this deterioration. This enzyme catalyzes the hydrolytic removal of methoxyl groups from the pectin molecule, an action that results in the formation of low ester pectins.

When the PM activity of the juice is low, the stability of the product during storage is increased. When the PM activity is high, a serious loss in quality is caused by the separation of serum from solids, or the concentrate may form a gel. This tendency to separate or gel is affected by the temperature at which the product is held. Low storage temperatures of the order of 0° F. furnish good protection for orange juice concentrate, but to maintain good consumer acceptance and uniformity of the product the added protection afforded by low enzyme activity in the juice must be provided.

By carefully controlled application of heat exchange, inactivation of enzymes has been possible *(3, 4)*. The close control of this process is necessary because of the heat-sensitive character of the juice components.

The present report concerns the effect of microwave energy on the inactivation of enzymes. Preliminary experiments with the Radarange[b] had indicated that orange juice concentrate could be heated readily with this equipment, at a frequency of 2450 mc. and an RF power output of about 1500 W.

The process involved absorption of microwaves by the concentrate, accompanied by a corresponding rise in temperature. This absorption was selective, occurring in the juice and essentially not in the glass of the containers used. Because with this type of irradiation there was no exchange of heat between a hot surface and the concentrate, as in conventional exchanges, energy absorption was not dependent on contact surface area or on a heat differential existing between such a surface area and the concentrate. The danger of overheating was, therefore, less. The radiation (and, therefore, the heating) was subject to close control, for it occurred only while the power tube (magnetron oscillator) was activated.

EXPERIMENTAL

Microwave applicator. Based on the results with the Radarange[b] electronic oven, a special microwave applicator has been constructed that utilizes a counter-flow system for exposing the concentrate to the radiation from a helical director or antenna. The device consists of concentric glass bowls arranged so as to receive the radiation from above and is equipped with inlet and outlet lines for the fluid. The design permits heat recovery by

[a] This paper is based in part on a thesis entitled "Some Aspects of Orange Juice Processing by Super Voltage Cathode Rays and by Microwave Radiations," submitted by the author to the faculty of the Massachusetts Institute of Technology in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Food Technology.

[b] Trade Mark of the Raytheon Manufacturing Co., Waltham, Mass.

incoming concentrate from the heated product flowing out. This is illustrated in Figure 1.

The concentrate enters through the outside channel, filling it to the lip of the inner bowl. It then flows evenly down and over the surface of the inner bowl, is exposed to the helix, and leaves through the inner or center channel. A level is maintained in the inner bowl at L (Figure 2) by throttling the flow. This is an arbitrary level chosen so that measurements will be made under fixed conditions. However, with fluid at approximately this level, the load exposed to the helix is continuous around the cavity formed by the partially filled inner bowl. This is a desirable arrangement from the standpoint of interception of microwave radiation. It is also necessary to have enough volume for expansion of product in the region of greatest heating. This condition is met by having most of the inner bowl empty. The counter-flow device is covered but not sealed.

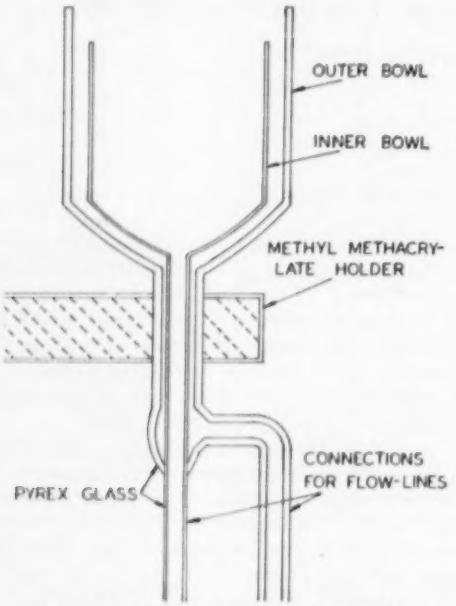

Figure 1. Diagram of counter-flow device.

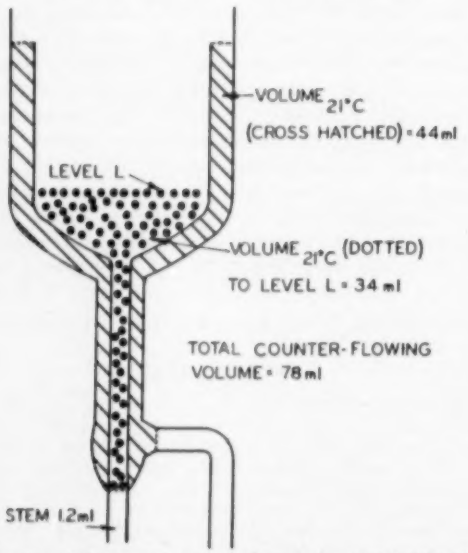

Figure 2. Diagram of counter-flow device showing levels of volumes occupied by fluid in parts of the device, using outer channel.

A power supply for the QK-312 air-cooled magnetron and a waveguide transmission to the helical director complete the experimental arrangement. This magnetron is a continuous-wave, fixed-frequency oscillator designed to operate in the 12.25-cm. band with 700 watts of average power output.

A diagram of the complete system as arranged for operation is shown in Figure 3.

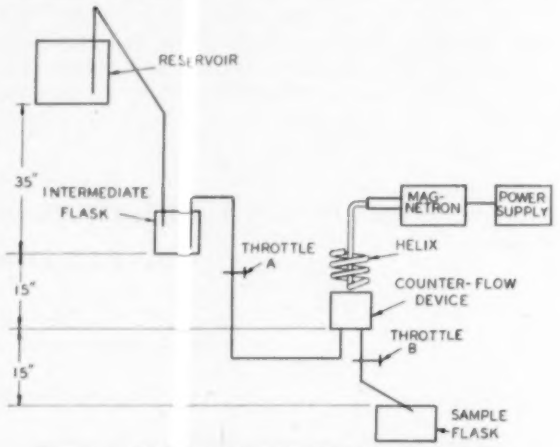

Figure 3. Diagram of counter-flow irradiation system.

In calibration of the device with water, the recovery of microwave energy as heat ranged from 71 to 92%.

Flow rate. Two throttles are indicated in Figure 3, that is, at the inlet side (A) and at the outlet side (B). Level L is maintained by adjustment of these two throttles. The flow rate obtained with this system is 107 ml. per minute.

Temperature of irradiated concentrate. The concentrate used in the tests was adjusted to an initial temperature of 23° C. The temperature at the outlet was dependent on the magnetron anode current, as follows:

I.	120 ma.	54° C.
II.	230 ma.	66° C.
III.	250 ma.	80° C.

The outlet temperatures were affected by some heat transfer to the incoming product. The irradiated product was cooled by collecting it in a mixture of ice and water. The final temperature after thus collecting the samples was not over 28° C.

Sampling. Sampling was carried out by collecting 25 to 30 ml. of the irradiated concentrate in 20 ml. of the cooling mixture. Control, non-irradiated samples were drawn from the same system with the power off, and 5-ml. aliquots were reconstituted (3 to 1) for duplicate tests.

Measurement of enzyme activity. Analysis for enzyme activity was made on a sample of the cooled mixture. The method used was that reported by MacDonnell, Jansen, and Lineweaver *(2)*. The rate of formation of carboxyl groups as a result of enzyme action on the pectin molecule may be measured by this method, the amount of neutralization of added alkali under standard conditions being dependent on the activity of the PM present. The activity was measured in an aliquot of the cooled mixture, 4 to 6 readings of time and alkali normally being made. The amount of alkali added was that shown by trial to be neutralized by the carboxyl groups liberated quickly enough to permit this number of observations within the optimum activity period, i.e., 11 to 15 minutes. This amount of alkali was dependent on the length of time the sample had been irradiated.

Method of calibration of equipment. Voltage standing wave ratios were obtained in order to determine the impedance match and extent of power reflection from the concentrated orange juice flowing through the device. Reference to the Rieke diagram gave the power available for the load in operation. The magnetron current supply shown in Table 1 and the calibrated power output associated with each amperage are shown in Table 2.

TABLE 1

Effect of microwave irradiation in counter-flow system on inactivation of pectin-methylesterase in orange juice concentrate

Sample	Magnetron power supply		PM. u./ml.[1] (reconstituted basis)
	Milliamperes	Kilovolts	
			x 10^4
Control	0	0	14.9
Control	0	0	14.7
I-A	120	3.8	1.24
I-B	120	3.8	1.21
I-C	120	3.8	1.08
I-D	120	3.8	1.14
II	230	4.1	All samples without enzyme activity
III	250	4.15	

[1] PM. u. (or PE. u.) is the quantity of enzyme that, under standard conditions, will catalyze the hydrolysis of pectinic acid at an initial rate of one milli-equivalent of ester bonds per minute.

TABLE 2

RF power levels and anode current values used in tests

Watts	Milliamperes
279	120
580	230
640	250

RESULTS AND DISCUSSION

The results obtained when samples of concentrated orange juice were exposed to microwave irradiation are summarized in Table 1, the results being identified with the magnetron power supply at the time the samples were obtained from the system. The concentrate used had not been heated prior to irradiation and had ample PM activity, as shown by the results obtained with the control samples.

The PM in the concentrate was inactivated by microwave radiation in the counter-flow system at a flow rate of 107 ml. per minute or 6.42 liters per hour when the RF power available was approximately 580 watts, but not when it was 279 watts. Referring to Table 1, these two levels of power are associated with samples II and I, respectively.

Microwave irradiation of a fluid was found to offer certain advantages, because of convenience in handling. The recovery of heat was facilitated. The fluid in this case was concentrated, and this reduced the volume of material to be irradiated. One objective of the investigation was to present the product to the radiation in such a way as to heat it quickly for inactivation of the enzyme, and then provide for a decrease in temperature to avoid side effects from the heat.

Movement of the fluid within the irradiated space had the effect of averaging out the energy transfer with respect to any specific portion of the fluid. As the fluid was of constant composition, the load presented to the microwave energy was constant, even though the load was actually flowing in the device. With the helix and a moving fluid load, a given volume of product is, therefore, presented to many successive portions of the radiation pattern rather than to a single fixed location and pattern.

Cost of microwave irradiation. For the purpose of calculating the cost of microwave irradiation of concentrated orange juice, a plant that processes 21,200 boxes of fruit daily on a 24-hour operating basis may be considered. The calculation may be modified as necessary, to consider interruptions for cleaning evaporators and other equipment.

Table 3 gives the cost data for this type of installation.

The elements of cost, electric power, and RF power tubes as estimated would be subject to downward revision for the power which would be saved in operation by counter-flow recovery of heat. Another basis for lower cost is in the life of the magnetron tubes which could be expected to be in excess of that used in the cost calculations. Here only the certified life has been used. There may be as much as a 3-1 difference, approximately, between certified and expected life. The stated cost of $125.00 per 1000 KWH of RF is based on the manufacturer's tube testing results and production costs at this time.

TABLE 3

Cost data for microwave irradiation in plant processing 21,200 boxes of oranges daily

Yield of concentrate per box (1952 basis)	1.42 gallons
Production per day	30,100 gallons
6 oz. cans per line based on two line production	3.67 cans per second
RF Power demand per line	150 KW
RF Power for two lines per season	1,080,000 KWH
Magnetron tube cost per season based on $125 per 1000 KWH RF	$135,000
Cost per season of electric power based on 60% conversion and $0.012 per KWH	$21,600
Cost per season for capital equipment amortized over a ten-year period at $5000 per 10 KW unit	$15,000
Total seasonal cost for process	$172,000
Cost per can	$0.00181
Cost of microwave irradiation based on yearly product value	1.2%

SUMMARY

Pectin-methylesterase in orange juice concentrate was inactivated in a new counter-flow system that utilized the microwave output of a magnetron with waveguide transmission to a helical antenna. The laboratory-scale operation of the system was at a flow rate of 6.42 liters per hour. At this rate, the power utilized was submaximum for the magnetron used.

For industrial use, the cost per season for power for two lines was estimated at $21,600. In a typical plant operation producing 13,200 cans per hour per line, the cost of magnetron tubes for the two lines was estimated at $135,000 per season. The resulting cost for tubes, power, and capital equipment was 0.181 cent per 6-ounce can.

Acknowledgments

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The Fluorescence of Liquid Egg. I. The Relation Between the Fluorescence and the Mustiness of Frozen Whole Egg

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There was no significant difference between the fluorescence of a clear serum extracted from normal samples and from musty samples of frozen whole egg when the fluorescence was measured at a fixed pH. When the serum was treated with sodium hydrosulphite under standard conditions, the fluorescence of the serum from normal material decreased and the fluorescence of the serum from defective material increased. The extent of the increase of fluorescence was related quantitatively to the intensity of mustiness in the original frozen egg.

The quality of frozen egg is occasionally impaired by the action of bacteria on the liquid before it is frozen. A sour smell and taste—the result of general bacterial multiplication—is probably the most common cause of inedibility but mustiness—a more serious fault—is caused by specific bacteria. Since the review by Jensen *(12)*, papers on these specific organisms have been published by Richard and Mohler *(22)* and Szybalski *(24)*.

Much work has been devoted to relating the bacterial content of frozen egg to other properties of the material but the "drill and smell test" is still the chief test of edibility. Although it is recognised that an expert appraisal of the smell or taste of a freshly-drilled sample is of great value, the possibility of establishing objective standards has often been discussed. Unfortunately, it is only gross defects in smell and taste that are usually accompanied by significant physical or chemical changes; nor is it easy to specify a permissible total viable count since the number is influenced by the rate of freezing and the time and temperature of storage in the frozen state *(30, 31)*.

The work described here was undertaken because some of the frozen whole egg recently examined in the United Kingdom suffered from a form of mustiness. It was suspected that specific bacteria were responsible for the fault but as the material had been pasteurised before freezing, it was not surprising that a search for such bacteria proved of no avail; the usual analytical tests also revealed nothing abnormal. It has been found that the defective material could be distinguished by a change in the intensity of fluorescence in ultraviolet light brought about by the addition of sodium hydrosulphite (dithionite) to a clear serum extracted from acidified whole egg; with normal material, the fluorescence decreased, with defective material, it increased. The extent of the increase was found to be related to the intensity of the taint; the flavour score awarded by a tasting panel bore an approximately logarithmic relation to the increase of fluorescence.

That the defect was actually caused by specific bacteria was rendered probable by work to be described in a later paper. Suspensions of *Pseudomonas putida* isolated from cold-stored eggs by Richard and Mohler *(22)* were injected into fresh shell eggs. The characteristic earthy, musty, raw-potato smell and taste appeared in a few days within the eggs, and rapidly increased in intensity; the fluorescence of a serum extracted from an acidified mixture of the white and yolk increased to a corresponding extent when the serum was treated with $Na_2S_2O_4$.

MATERIALS AND METHODS

Materials. The commercial frozen egg contained a small amount of sodium citrate that had been added to serve as an anti-coagulant during batch-pasteurisation *(26)*. The 28-lb. tins were thawed by immersion in cold, running water, the tins being shaken from time to time. The contents of the tin were poured into a large bowl and thoroughly mixed before sampling. Unless otherwise stated, the measurements described below were made on this commercial frozen egg.

Preparation of the serum. The serum was prepared by the method described by Reid *(21)*: 50 g. of liquid whole egg were shaken vigorously by hand for 30 seconds with 100 ml. $CHCl_3$, and the emulsion was immediately centrifuged for 15 minutes at 2000 r.p.m. The clear, aqueous layer was pipetted off; if it became contaminated by the underlying emulsion during pipetting, it was centrifuged again or filtered. The values set out below show that the time and rate of shaking with $CHCl_3$ had little influence on the fluorescence of the serum.

FLUORESCENCE [1] OF THE SERUM AT pH 6

Shaken by hand for ½ minute	67.4
Shaken mechanically for 5 minutes	64.1
Shaken mechanically for 15 minutes	62.6

[1] In units as defined below.

The results of analyses of typical samples of whole egg and serum from fresh eggs are given in Table 1. The values indicate that shaking whole egg with $CHCl_3$ precipitates practically all the lipids and about 48% of the proteins.

TABLE 1
Composition of whole egg and egg serum

	Percent by weight		
	H_2O	Lipid [1]	Protein [2]
Whole egg	74.0	11.8	12.7
Egg serum	90.5	0.0023	8.1

[1] Calculated from the results of a $CHCl_3$ extraction of dried whole egg or serum.
[2] Percent Kjeldahl nitrogen x 6.25.

The measurement of fluorescence. The fluorescence of the serum was measured by means of a Coleman photofluorometer using the filters B1 (Corning No. 5874 transmitting mainly 365 mμ) and P61 (Corning Nos. 3389-4308) supplied for the estimation of thiochrome. The instrument was so adjusted before each measurement that a scale reading of 40 units was given by a reference solution of 0.1N.H_2SO_4 containing 0.1 μg. of quinine sulphate per ml. after the blank reading given by a cuvette containing either 0.1N.H_2SO_4 or H_2O had been balanced out by a

manipulation of the blank and balance controls. The measurements were made at room temperature; the readings for serum were practically independent of the temperature between 15° C. (59° F.) and 30° C. (86° F.). Stock solutions of quinine sulphate were kept in the dark at 0° C. (32° F.), and solutions in use were kept in bottles of brown glass and renewed frequently.

Occasionally, the intensity of fluorescence exceeded the full scale reading of 100 units. In such instances, the amount of exciting light was reduced by the insertion of a mask with a circular aperture between the mercury lamp and the cuvette, and a reference solution containing more quinine sulphate was used. It was possible, however, to express the results in terms of 40 units per 0.1 μg. quinine sulphate per ml. since the fluorescence-concentration curve for quinine sulphate was found to be sensibly linear under such conditions over a wide range (Table 2).

TABLE 2

The fluorescence of solutions of quinine sulphate in 0.1 N.H_2SO_4.[1]

Concentration of quinine sulphate (μg. per ml.)	Reading	Fluorescence (F) in terms of 40 units per 0.1 μg. per ml.	F/μg.
0.025	9.6	9.6	384
0.05	18.6	18.6	372
0.075	29.6	29.6	395
0.1 (R. S.)	40.0	40.0	400
0.2	83.8	83.8	419
0.2	16.7	83.5	419
0.5 (R. S.)	40.0	200	400
0.75	59.2	296	395
1.0	80.0	400	400
1.0	20.2	404	404
2.0 (R. S.)	40.0	800	400
3.0	60.3	1206	402
4.0	79.5	1590	398

[1] The reference solution used in each of the three ranges is denoted by (R. S.).

Solutions of sodium hydrosulphite. Different commercial samples of the salt were found to contain from 88 to 77% $Na_2S_2O_4$. The purity of the solid slowly decreased with time; for example, it fell from 88 to 69% during 4 months at room temperature. The solutions were prepared immediately before use, and always contained 3.5% of active $Na_2S_2O_4$ (0.2 M.) and sufficient ammonia to give the desired pH. The aqueous ammonia was added to the solid and the mixture was immediately covered with a layer of medicinal paraffin; solution of the solid was completed by stirring through the paraffin layer. The solid salt was analysed at intervals by the method described by Vogel *(27)*, and the titration curve relating the pH of the solution to the amount of added ammonia was checked from time to time. The pH measurements were made with a glass electrode, the solution being covered by a layer of paraffin. The pH diminished with time if the solution was exposed to air, and especially if the solution was stirred.

The adjustment of pH. Whole egg is heavily-buffered, and its pH usually lies between 7.2 and 7.8 *(6)*. The pH of the serum extracted from different samples usually ranged from 8.1 to 8.3; the increase was attributed mainly to loss of CO_2 during preparation. The fluorescence of the serum depended on its pH, the intensity being least when the pH was approximately 7.5. The most convenient way of lowering the pH was to add acid to the whole egg before shaking it with $CHCl_3$ and centrifuging; the direct addition of the larger amounts of acid to serum sometimes produced a turbidity[2] which was difficult or impossible to remove by centrifuging. A glass electrode was used to measure pH; with whole egg it was essential because of its high fat content to clean the electrode in an alcohol-ether mixture after each measurement, and to check its accuracy frequently.

The buffering capacity of different samples of whole egg or serum varied slightly amongst themselves. As would be expected from its composition, serum was not so heavily buffered as whole egg. Some results are set out in Table 3. The pH values refer to one sample; the values of ΔpH/Δml. are average values.

When acid is added directly to whole egg, it is advisable to standardise the intervals between the addition of acid, the extraction of the serum and the subsequent measurement of fluorescence. Thirty-minute intervals were found to be convenient;

TABLE 3

The effect on the pH of the serum of adding N.HCl to 50 ml. serum or to 50 g. whole egg

ml. N.HCl	0	0.5	1.0	1.5	2.0	2.5
Acid added to serum						
pH of serum	8.18	7.14	6.68	6.32	6.00	5.66
—ΔpH/Δml.	2.06	0.98	0.70	0.62	0.60	
Acid added to whole egg						
pH of serum	8.12	7.66	7.25	6.82	6.37	6.00
—ΔpH/Δml.	0.72	0.82	0.96	0.88	0.74	

considerably different intervals gave slightly different, but reproducible results. The presence of citrate in the commercial material increased the buffering capacity; for example, it was only necessary to add 2.2 ml. N.HCl, instead of 2.5 ml., to 50 g. citrate-free whole egg in order to obtain a serum of approximately pH 6.

RESULTS

The influence of pH on fluorescence. The relation between the pH and fluorescence of serum is illustrated in Figure 1. In these experiments, various amounts of N.HCl were added directly to three samples of whole egg: normal frozen egg (A), musty frozen egg (B), and frozen egg containing 1% tri-sodium citrate prepared in the laboratory from fresh eggs (C). The difference between curves A and B was less than the variation

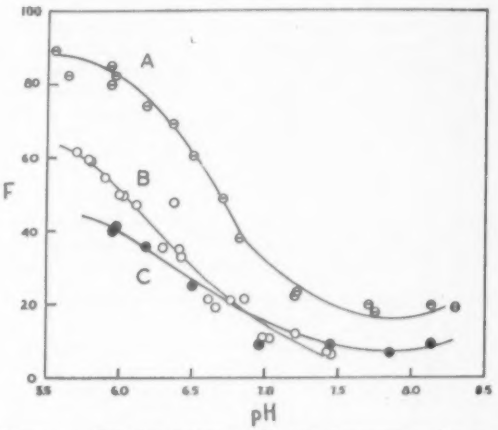

Figure 1. Relation between pH and fluorescence for serum from normal frozen egg (A), musty frozen egg (B), and experimental frozen egg containing citrate (C).

found in other experiments between normal samples; there was never, in fact, any correlation between fluorescence and mustiness when the fluorescence of the serum was measured at a given pH. The values set out below show that increasing the pH of serum above approximately pH 8 by the addition of alkali increased the fluorescence.

pH	7.16	8.23	8.63	10.1
F	23.1	26.9	31.3	43.8

Curves A and B in Figure 1 represent measurements that were made at intervals over a period of 4 months, the frozen egg having been kept in the meantime at —10° C. (14° F.). It will be seen that storage in the frozen state had little or no effect on fluorescence when it was measured at a fixed pH.

The effect of sodium hydrosulphite. *Normal egg serum.* Various amounts of N.HCl were added to whole egg and the fluorescence of 10 ml. samples of the serum was measured. A

[2] When liquid egg contains no citrate, actual precipitation may occur when the pH of the serum is lowered by the direct addition of acid.

solution of $Na_2S_2O_4$ of the same pH as the sample was then added to the cuvette—causing little or no alteration in pH—and the fluorescence of the mixture was measured 10-15 minutes later. The solution in the cuvette was sometimes covered with a layer of paraffin after the addition of $Na_2S_2O_4$ but it was not essential to do so.

It was found that the fluorescence of normal serum was quenched by $Na_2S_2O_4$, the extent of quenching being proportional to its concentration. Figure 2 illustrates the quenching of serum

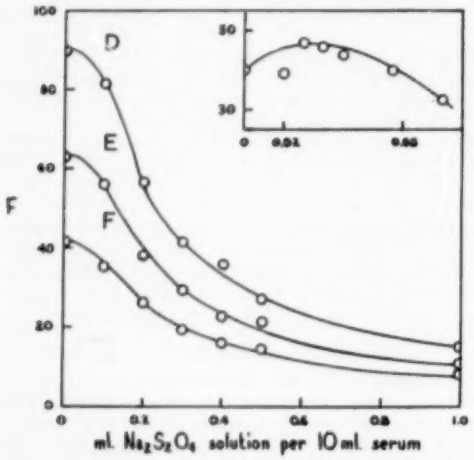

Figure 2. Fluorescence quenching by $Na_2S_2O_4$ of serum from two samples of normal commercial frozen egg (D and E), and a sample of experimental frozen egg containing citrate (F).

from two different samples of normal frozen egg (D and E) and a sample of frozen egg containing citrate (F) that was prepared in the laboratory. The pH of the serum from D, E and F was 5.55, 5.93 and 5.98, respectively. The relation between the concentration of $Na_2S_2O_4$ and the fluorescence was in reasonable agreement with the Stern-Volmer equation *(23)*:

$$\frac{F}{F_o} = \frac{1}{1 + kc}$$

where F_o is the fluorescence in the absence of the quencher, F is the fluorescence when the concentration of quencher in the final mixture is c, and k is a constant. In Figure 3, c is expressed in the usual units of g./ml. and is plotted against $\left(\frac{F_o}{F} - 1\right)$

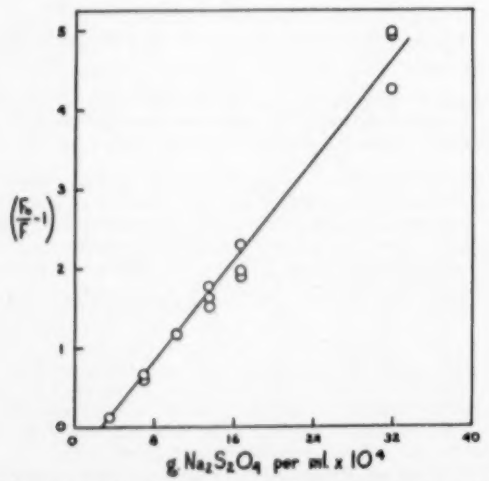

Figure 3. Data of Figure 2 plotted in accordance with the Stern-Volmer equation.

using the data shown in Figure 2. The points for all the 3 samples lie close to the same line; the value of k, which is given by the slope of the line, was 1490. Thus, within the range studied, k was independent of the source of the egg, the initial fluorescence of the serum and its pH between 5.6 and 6.0. Hydrosulphite is a powerful quencher; the value of k for the quenching of the fluorescence of acriflavin solutions by KI is 430 *(18)*.

The failure of the line in Figure 3 to pass through the origin is probably caused by the oxidation of a little $Na_2S_2O_4$ by serum constituents. If this is so, the loss of $Na_2S_2O_4$ is given by the intercept on the abscissa, and amounts to 2.1×10^{-6} g. $Na_2S_2O_4$ in 10 ml. serum (corresponding to 0.06 ml. $Na_2S_2O_4$ solution). Combination of $Na_2S_2O_4$ with the atmospheric oxygen dissolved in the serum according to the following equation *(7)*:

$$Na_2S_2O_4 + O_2 + H_2O \longrightarrow Na_2S_2O_5 + H_2O_2$$

would account approximately for one-quarter of the loss, or for one-half after the reduction of the H_2O_2 formed in the reaction. When less than 0.1 ml. $Na_2S_2O_4$ solution was added to 10 ml. serum there was actually a small increase of fluorescence (inset of Figure 2).

The fluorescence of normal egg serum was also quenched by other anions; the calculated values of the quenching constant of $NaNO_2$ are given below. With this salt, the plot of $\left(\frac{F_o}{F} - 1\right)$ against c passed through the origin. The values are:

g. $NaNO_2$ per ml. serum x 10^4	3.41	6.82	13.6	27.3
k	419	411	411	416

Of the other salts tested, $K_3Fe(CN)_6$ and $K_4Fe(CN)_6$ proved to be strong quenchers, and KI and KCNS, weak quenchers.

Musty-egg serum. The results of adding different volumes of $Na_2S_2O_4$ solution of pH 6 to a serum of the same pH are set out in Table 4; the serum was extracted from an acidified sample of one of the mustiest tins of frozen egg available.

TABLE 4

The effect of adding increasing amounts of $Na_2S_2O_4$ to musty-egg serum of pH 6

ml. $Na_2S_2O_4$ solution per 10 ml. serum	pH of mixture	F
0	6.00	60.0
0.1	5.96	207
0.2	5.98	152
0.3	5.93	107
0.4	5.95	86.9
0.5	5.98	63.4
1.0	5.93	31.7

The addition of 0.1 ml. $Na_2S_2O_4$ solution increased the fluorescence by almost 150 units (ΔF); progressively smaller increases were obtained when larger volumes were added. With 1 ml., the fluorescence was reduced below the original value but only by about one-half, whereas with normal serum the reduction would have been five-sixths. With less musty samples, the increase of fluorescence on adding 0.1 ml. $Na_2S_2O_4$ solution was not so large, and less than 1 ml. was required to reduce the fluorescence below the original value.

The effect of pH. Figure 4 shows the effect of adding 0.1 ml. $Na_2S_2O_4$ solution to 10 ml. samples of serum extracted from a moderately musty (G), a slightly musty (H) and a normal sample (I) of frozen whole egg after acidification to various degrees; ΔF is the change of fluorescence brought about by the addition of $Na_2S_2O_4$ solutions of the same pH as the serum. The fluorescence of normal serum was quenched slightly at pH 6, at pH 6.3 there was usually a small increase, and little or no change at higher values of the pH. The curves showed that the greatest difference between normal and musty material was likely to be displayed when the pH of the serum was in the neighborhood of 6.

The quenching and enhancing action of $Na_2S_2O_4$. Hydrosulphite seems to act principally as a quencher in normal serum. If the $Na_2S_2O_4$ present is destroyed by adding excess H_2O_2 or by shaking the mixture with air, the fluorescence rises to approximately the original value; apparently neither H_2O_2 nor $Na_2S_2O_5$ is a strong quencher. In musty-egg serum, $Na_2S_2O_4$ apparently

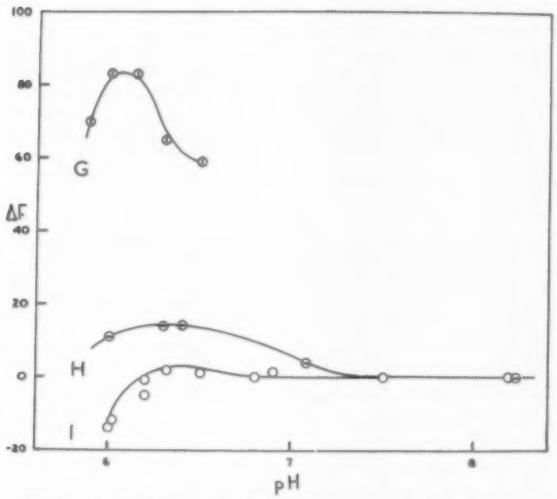

Figure 4. Influence of pH on the value of △F for serum from a moderately-musty (G), a slightly musty (H), and a normal sample (I) of commercial frozen egg.

plays two parts; as its concentration is increased, the fluorescence rises and then falls. It seems likely that the fall is caused by quenching. The results set out in Table 5 show that both the rise and the fall were reversed when the $Na_2S_2O_4$ present in the mixtures was oxidised by the addition of excess H_2O_2 (2 ml. of 10 vol. % H_2O_2 per 10 ml. serum). Similar results were obtained by shaking with air.

TABLE 5

The effect of destroying the $Na_2S_2O_4$ present in musty-egg serum of pH 6.1

ml. $Na_2S_2O_4$ solution per 10 ml. serum	Fluorescence (F). After adding $Na_2S_2O_4$	Fluorescence (F). After adding H_2O_2
0	(60.4)	51.0
0.1	85.7	57.0
0.2	69.3	56.0
0.3	50.0	55.0
0.4	43.6	54.0
0.5	34.3	53.5
1.0	19.3	51.0

The maximum increase of fluorescence occurred when the amount of added $Na_2S_2O_4$ was of the same order as that required to combine with all the dissolved oxygen in the serum. The fluorescence of a number of solutions is quenched by molecular oxygen *(3, 4, 11, 13, 28)*, and it was tempting to conclude that musty-egg serum contained solutes with similar properties. No change of fluorescence was observed, however, when oxygen was removed from such a serum by repeated evacuations, followed by flushings with oxygen-free nitrogen, in an all-glass apparatus that permitted the measurement of fluorescence without exposing the serum to air. It is possible that musty-egg serum contains compounds that fluoresce after chemical reduction by $Na_2S_2O_4$ but do not do so in the oxidised state, and that when the amount of $Na_2S_2O_4$ added is in excess of that required to combine with dissolved oxygen and then to act as a reducing agent, both the normal and the "extra" fluorescence are quenched. If it is assumed that normal and "extra" fluorescence are independent, it is possible to show that the decrease in the latter as the concentration of $Na_2S_2O_4$ is increased, obeys the Stern-Volmer equation fairly well, and that the quenching constant is not very different from that of normal serum.

The relation between mustiness and enhanced fluorescence. For comparative purposes, the thawed whole egg was acidified before the extraction of the serum, and the change of fluorescence (ΔF) caused by the addition of 0.1 ml. $Na_2S_2O_4$ solution to 10 ml. serum of pH 6 ± 0.1 was measured. To obtain such a serum, a trial was made with a mixture of 50 g. whole egg and 2.5 ml. N.HCl. If the pH of the serum lay outside the limits, the volume of acid added to a further 50 g. sample was altered in accordance with the values of ΔpH/Δml. in Table 3. With such a small volume of $Na_2S_2O_4$ solution it was not essential that its pH should be exactly 6.0.

Later work indicated that an even greater differentiation between normal and musty material might have been obtained if a pH of 6.3 and a volume of 0.05 ml. $Na_2S_2O_4$ solution had been chosen. Nevertheless, the conditions adopted had the advantage that ΔF for normal material was always negative, and always positive, with one exception, for musty material; furthermore, the adjustment of pH and $Na_2S_2O_4$ concentration did not need to be so precise.

The average value of (—ΔF) for the normal samples of commercial frozen egg examined was 9 units (range 7 to 15 units). Nine units were therefore added to the ΔF values of other samples to give ΔF′, where:

$$\Delta F' = (\Delta F)_M - (\Delta F)_N = (\Delta F)_M + 9$$

The subscripts M and N denote the unknown serum and the average normal serum respectively.

The tins of commercial frozen egg had previously been examined by official graders by the "drill and smell" test; baking tests had also been carried out on tins known to have been drawn from the same batches after pasteurisation. For comparative purposes, however, the thawed material was tasted in the raw state by a laboratory tasting panel, and marks were awarded on the following scale:

	Flavour score
No detectable mustiness	8
Barely-detectable mustiness	7
Definite mustiness	6
Mustiness increasingly pronounced	5–4–3
Increasingly pronounced to repulsive and inedible	2–1–0

A similar scale has been used in this laboratory for shell eggs and dried eggs for several years *(2)*. The relation between the flavour score and ΔF′ is illustrated in Figure 5; the flavour

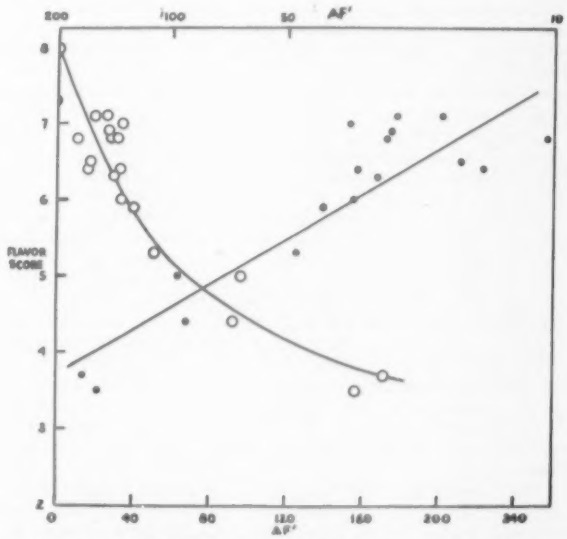

Figure 5. Relation between the flavor score of thawed egg and both △F′ (O) and $\log_{10}$ △F′ (●).

scores were probably reliable to within one-half a unit in the upper half of the scale. There was a reasonable correlation between the two variables, and the plot of log ΔF′ against flavour score was approximately linear.

The results of the three tests—drill and smell, tasting, and fluorescence—failed to agree in only one instance; a sample

judged to be slightly musty by the first two tests gave a $\Delta F'$ value of minus one unit. Most of the tins of musty, commercial frozen egg encountered were tainted only to a slight degree, and it was difficult to find examples with flavour scores below 6 or values of $\Delta F'$ above 40 units. When $\Delta F'$ was positive and less than 20 units, mustiness was often undetectable in the finished sponge cake although it was perceptible when the raw egg was smelled or tasted, or when the sugar-egg mixture was whisked during the preparation of a sponge cake (this was so in the case of the discrepant sample). At higher values of $\Delta F'$, the taint was usually apparent in the finished sponge cake.

Additional Results

Effects of freezing and the presence of citrate. Liquid whole egg prepared from fresh eggs was frozen at —20° C. (—4° F.). As would be expected, freezing and thawing had little or no effect on the buffering capacity of the thawed liquid or the serum prepared from it. In some instances, 1% of tri-sodium citrate was dissolved in the liquid before freezing.

Reid *(21)* observed that the serum (presumably of approximately pH 8) extracted from whole egg had a lower fluorescence if the liquid egg had previously been frozen; storage of the frozen egg for 6 months at various temperatures did not alter the fluorescence appreciably. The present work confirmed these results, and showed that the effect of freezing was more evident when the pH of the serum was lowered (Table 6).

TABLE 6

The effect of freezing and thawing fresh whole egg on the fluorescence of the serum

pH of serum	5.5	6.0	6.5	8.0
F before freezing	63.9	43.7	21.0	23.1
F after freezing	35.1	18.0	15.6	15.7

The presence of citrate completely prevented the differences shown in Table 6, the fluorescence of a serum at a fixed pH being the same, regardless of whether or not the whole egg had previously been frozen. As the presence of citrate also prevented the marked increase of viscosity—caused by a change in yolk constituents—that normally accompanies the freezing and thawing of whole egg *(17, 25)*, it seemed possible that both effects were related. On this basis, it would seem that part of the fluorescence of the serum was derived from yolk constituents, and that these compounds were not extracted in the serum—or extracted in an altered form—when the whole egg had previously been frozen in the absence of citrate.

Changes of pH during frozen storage. Pearce and Reid *(19)* made the interesting observation that the pH of frozen whole egg prepared from strongly-musty shell eggs decreased from 7.7 to 6.8 during storage in the frozen state for 12 months, whereas the frozen material prepared from other types of eggs showed much smaller increases. In an earlier paper, Reid *(21)* had reported that the fluorescence of the serum extracted from musty material stored in the frozen state for 6 months at various temperatures increased by 5-17%. It seems likely that these, and other changes of fluorescence observed by the Canadian workers during the freezing and storage of material prepared from eggs of different quality were a reflection of the influence of pH on fluorescence. No definite changes of pH were observed in the present work when frozen egg was stored for 4 months at —10° C. (14° F.) but the period of storage was shorter, and mustiness was probably less pronounced than in the Canadian experiments.

Self quenching. The fluorescence-concentration curves given by some solutes are not linear, and the fluorescence may even reach a maximum and then decrease as the concentration increases. In some instances, this is because the product of the absorption coefficient and the concentration of the solute is not small within the working range or because of geometrical factors connected with the particular instrument employed; in other instances, it is because the quantum efficiency diminishes with increasing concentration; that is, the solutions are truly self-quenched *(5, 20)*.

When egg serum of pH 6 or thereabouts was diluted with H_2O or a 0.85% solution of NaCl, the fluorescence did not diminish to a corresponding extent, and with a serum near pH 8 the much smaller initial fluorescence actually increased. Both diluents gave practically the same results, and neither of them altered the pH of the serum appreciably. As the compounds responsible for the fluorescence of serum are unknown, it cannot be concluded that the liquid is truly self-quenched. Nevertheless, it is interesting to estimate the relation between dilution and fluorescence. The results of an experiment with a serum of pH 5.75 from commercial frozen egg are set out in Table 7.

TABLE 7

The effect on fluorescence of dilution of 10 ml. serum of pH 5.75 with y ml. 0.85% NaCl solution

y (ml.)	F_d	pH	r	—k
0	81.9 = F	5.75	1	
2.5	76.8	5.73	1.172	1.83
5.0	75.2	5.75	1.371	1.89
10.0	70.5	5.80	1.721	1.81
15.0	63.5	5.82	1.939	1.83
20.0	58.2	5.86	2.130	1.81

The first column contains the volume of 0.85% NaCl solution (y ml.) added to 10 ml. serum, and the fourth column the values of the relative fluorescence (r) where:

$$r = \frac{(10 + y)F_d}{10F}$$

and F and F_d denote the fluorescence of the serum before and after dilution. If there was no quenching, the value of r would be constant. It will be seen from the table that when the concentration of the fluorescing compounds in serum was reduced to one-third, the relative fluorescence was more than doubled. The fifth column of the table contains the values of k calculated from equation (1) when k' equals 0.925. Equations in which the fluorescence is related to an exponential function of the concentration have been applied to the self-quenching of other solutions.

$$\frac{10}{10 + y} = k \log_{10} r + k' \qquad (1)$$

The manner in which a serum of pH 7.7 responded to dilution with 0.85% NaCl solution is shown by the data in Table 8; the last column gives the values of k obtained from equation (1) when k' equalled unity. A comparison of the values in the fourth columns of Tables 7 and 8 will show that quenching was much more pronounced at pH 7.7 than at pH 5.8.

TABLE 8

The effect on fluorescence of dilution of 10 ml. serum of pH 7.7 with y ml. 0.85% NaCl solution

y (ml.)	F_d	pH	r	—k
0	15.2 = F	7.70	1	
2.5	19.7	7.72	1.622	0.95
5.0	21.0	7.68	2.073	1.05
10.0	23.5	7.64	3.092	1.02
15.0	23.5	7.66	3.865	1.02
20.0	22.2	7.68	4.386	1.04

DISCUSSION

The work described above, and that to be described in a later paper, indicated that the mustiness of the commercial material was probably caused by *Pseudomonas* bacteria, and that the degree of mustiness was related quantitatively to a change in the fluorescent properties of the material. A specific test for mustiness would be welcome; the later work showed, however, that a positive value of $\Delta F'$ was not peculiar to the serum of musty eggs but could also be caused by a species of *Pseudomonas* that did not produce mustiness.

Nevertheless, measurements of fluorescence may prove to be useful. Although every species of *Pseudomonas* does not produce mustiness in eggs, they all

seem to produce off-flavours of one sort or another. Moreover, it seems to be true that mustiness in eggs is nearly always caused by *Pseudomonas* bacteria *(24)*. Nor are the undesirable results of *Pseudomonas* infection confined to frozen egg; the part played by these organisms in the spoilage of washed eggs during storage is well known.

Analogies can be found in the behaviour of other systems for many of the effects observed with egg serum but the complexity of even normal serum makes it unwise to draw conclusions without further evidence. It is not known why small amounts of $Na_2S_2O_4$ should increase the fluorescence of a serum from defective material, and why the effect should be reversed by oxidising agents. Reversible quenchings of fluorescence by oxidation-reduction mechanisms are known to occur; for example, in the interaction of methylene blue and ferrous ions *(29)*, but in this example, and in the case of thiamin-thiochrome and leucoriboflavin-riboflavin, it is the oxidised form of the compound that fluoresces. It must also be remembered that the serum contains proteins, and that adsorptive effects can influence fluorescence *(9)*. Furthermore, when a solution contains more than one fluorescing compound, the compounds do not necessarily fluoresce independently of each other *(10)*, and such systems might react in a peculiar manner to the addition of such an active substance as $Na_2S_2O_4$.

The fluorescence of serum depends on its pH and it is interesting that the shape of the pH-fluorescence curve bears no resemblance to that of riboflavin *(8, 14, 15)* which is present in the egg or to those of lumiflavin, lumichrome or thiochrome *(14, 16)*. It should be remembered, however, that Bain and Deutsch *(1)* found that at least part of the riboflavin in egg white is bound to conalbumin.

SUMMARY

The fluorescence of a clear serum extracted from normal and musty samples of commercial frozen whole egg was measured. The intensity of fluorescence depended on the pH of the serum, and was least at approximately pH 7.5. There was no relation between fluorescence and mustiness when the fluorescence of the serum was measured at a fixed pH.

The fluorescence of the serum from normal samples was quenched by $Na_2S_2O_4$; the quenching constant of the Stern-Volmer equation was found to be the same for commercial and experimental material. The addition of $Na_2S_2O_4$ to the serum from musty frozen egg increased the fluorescence, the value rising to a maximum and then decreasing as the concentration of $Na_2S_2O_4$ was progressively increased. The extent of the increase measured under standard conditions of pH and $Na_2S_2O_4$ concentration was found to be related to the intensity of mustiness; the flavour score awarded by a tasting panel bore an approximately logarithmic relation to the increase of fluorescence.

The freezing and thawing of liquid whole egg decreased the fluorescence of the serum; the change was prevented when whole egg contained 1% of tri-sodium citrate. The dilution of serum did not quench the fluorescence to a corresponding extent; instead, the fluorescence was related to an exponential function of the extent of dilution.

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The Fluorescence of Liquid Egg. II. The Effect of Specific Bacteria

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When suspensions of two species of Pseudomonas bacteria were injected directly into shell eggs, the contents of the eggs became musty at an increasing rate. The intensity of mustiness was related quantitatively to a change in the fluorescent properties of the egg contents. Another species of Pseudomonas bacteria caused similar fluorescent changes but produced a different type of odour. The behaviour of a species of Aerobacter bacteria was studied.

In an earlier paper *(1)* it was shown that the degree of mustiness of certain commercial samples of frozen egg was quantitatively related to a change in their fluorescent properties. As the material had been pasteurised before freezing, it was not surprising that bacteriological examinations failed to reveal the cause of the defect. The present paper describes the effects of injecting suspensions of bacteria originally isolated from "heueier" by Richard and Mohler *(3)* into shell eggs.

The term "heueier" is used in Europe to denote defective eggs that are difficult or impossible to detect by candling, and the contents of which possess a smell that has been described as that of damp, musty hay or of damp, rotting root-crops. The defect was once attributed to the uptake of odours from unsuitable packing materials *(2)* but Richard and Mohler *(3)* have prepared from such eggs pure cultures of different bacteria, some of which were able to produce the characteristic smell in culture media or after penetration into fresh eggs.

MATERIALS AND METHODS

Eggs. Clean eggs that had not been washed were used. Half the eggs of a batch were injected with bacteria. Control and injected eggs were stored at 20° C. (68° F.) and a relative humidity of approximately 50%, and sampled at intervals. Each sample consisted of six eggs; the white of each egg was examined in ultra-violet light before the six whites and yolks were mixed together. Two types of eggs were used: either eggs that were injected a few days after laying and were kept at 0° C. (32° F.) in the meantime, or eggs that had previously been kept at 25° C. (77° F.) for 21 days.

Injection of bacteria. A number of cultures[a] of each of the following bacteria were used: *Pseudomonas putida* (Trevisan) Migula, *Pseudomonas schuylkillensis* Chester, and *Aerobacter cloacae* (Jordan) Bergey *et al.* In addition, an unidentified *Pseudomonas sp.* was isolated from a musty, cold-stored English egg. After sub-culturing on casein-digest agar at 20° C. (68° F.), the organisms of 48-hour cultures were washed off the slopes by gentle agitation with sterile glass beads and saline. The number of organisms in the suspension was estimated by a direct microscopic count, and the suspension was diluted with sterile saline until it contained 10^8 organisms per ml.; 0.5 ml. of this suspension (about 10^8 organisms per g. of the egg contents) was injected by means of a sterile hypodermic syringe either into the air cell of an egg or into the white at the narrow end of the egg.[b]

[a] Kindly supplied us by Dr. O. Richard, Zurich, Switzerland.

[b] The air cells of very fresh eggs are not large enough to contain 0.5 ml. In such cases it is better to use 0.2 ml. of a more concentrated suspension and to drill two holes into the air cell instead of one.

Before injection, the egg was clamped in a sterile frame, and either the broad or narrow end was flamed twice with alcohol. The frame and the egg were placed beneath a sheet of glass, and subsequent operations were carried out from the side. A small hole, of a slightly greater diameter than that of the hypodermic needle, was drilled through the shell but not through the shell membranes. Two different lengths of needle were used; both of them were short in order to ensure that neither the inner shell membrane nor the yolk was pierced when bacteria were injected into the air cell or the narrow end of the egg, respectively. The arrangement also ensured that the suspension was delivered at similar locations in different eggs. After the injection, the hole in the shell was sealed with a drop of molten, sterilized paraffin-wax.

Measurement of fluorescence. The fluorescence of a clear serum of pH 6 ± 0.1 extracted from an acidified mixture of whites and yolks was measured before and after the addition of 0.1 ml. 0.2M.$Na_2S_2O_4$ (pH 6) to 10 ml. serum by means of a Coleman photofluorometer using the B1 and PC1 filters supplied for the estimation of thiochrome. The results were expressed in terms of a reference solution of 0.1N.H_2SO_4 containing 0.1 μg. quinine sulphate per ml.; the reading for this solution was set at 40 units after the blank had been balanced out. The procedure adopted with an intensely fluorescing serum has already been described *(1)*.

Adjustment of pH. The effect of adding acid to whole egg on the pH of the mixture and that of the serum prepared from it is shown in Table 1. There was a small variation between the buffering capacity of different lots of whole egg. The pH values in the table refer to one sample; the values of ΔpH/Δml. are average values.

TABLE 1

The effect of adding N.HCl to 50 g. whole egg on the pH of the mixture and of the serum

ml. N.HCl	0	0.5	1.0	1.5	2.0	2.5
pH of whole egg	7.57	6.98	6.45	6.25	5.86	5.52
pH of serum	8.18	7.80	7.36	6.78	6.20	5.76
ΔpH (serum)/Δml.	0.80	0.86	1.10	1.06	0.76	

RESULTS

Effect of time on untreated eggs. The observation of van Waegeningh and Heesterman *(6)* that the white of a stored egg displays a blue fluorescence in ultra-violet light whereas the white of a fresh egg hardly fluoresces at all was confirmed, according to Grossfeld *(2)*, by Haitinger and Reich, Zäch and Dingemans. After a visual comparison of the white of eggs of different ages with that of gelatin solutions of different concentrations, van Waegeningh and Heesterman *(6)* concluded that the fluorescence developed during storage at an increasing rate.

The fluorescence (F) of a serum of pH 6 was also found to depend on the age of the eggs from which the serum was prepared. When fresh eggs were kept at 20° C. (68° F.) and sampled at intervals, the fluorescence hardly altered during the first 2-3 weeks but increased thereafter at an approximately logarithmic rate. Figure 1 shows the results obtained with untreated batches of fresh eggs and eggs that had previously been stored. In both instances, the points represent the results of two separate experiments (cf. also Table 6). It will be seen that there was no "induction period" with eggs that had already been stored. A similar increase of fluorescence apparently occurs more slowly at 0° C. (32° F.); the fluorescence of serum (pH 6) prepared from oiled, cold-stored eggs of different origins is also plotted on a logarithmic scale against age in Figure 1.

The regularity of the results makes it unlikely that micro-organisms were responsible for the increase of fluorescence.

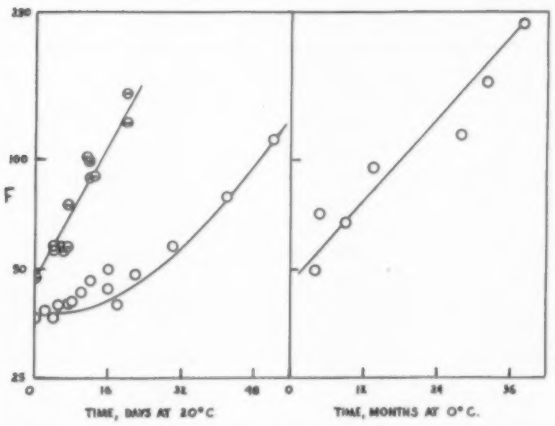

Figure 1. Relation between the fluorescence of the serum (pH 6) and the age of eggs kept at 0° C. (32° F.) and eggs kept at 20° C. (68° F.). At 20° C.: fresh eggs (O); eggs previously kept at 25° C. (77° F.) for 3 weeks (Θ).

Nevertheless, such measurements do not furnish a reliable guide to the exact age of an egg; the fluorescence of the serum prepared from small samples of fresh eggs of different origins varied from 29 to 59 units at pH 6, the average value being 36 units.

The fluorescence of the serum prepared from untreated eggs was quenched by $Na_2S_2O_4$. At pH 6, the average decrease caused by the addition of 0.1 ml. $Na_2S_2O_4$ solution to 10 ml. serum was 13 units; the value did not alter appreciably as the age of the egg increased.

Behaviour of Pseudomonas spp. The results obtained using *Pseudomonas putida* and stored eggs are set out in Table 2. As before, $\Delta F'$ is given by:

$$\Delta F' = (\Delta F)_i - (\Delta F)_c$$

where (ΔF) is the change in fluorescence brought about by the addition of $Na_2S_2O_4$ to a given serum, and the subscripts I and c denote serum from injected eggs and control eggs respectively.* The table also shows the proportion of "green white" detected in each sample; that is, the proportion of the six whites that could

TABLE 2

The effect of inoculating previously-stored eggs (3 weeks at 25° C.) with Pseudomonas putida

Days at 20° C.	N. E. eggs		A. C. eggs	
	$\Delta F'$	% green whites	$\Delta F'$	% green whites
0	0	0	0	0
7	5	0	50	0
8	40	17	350	100
12	80	17		
15	94	33		
20	285	33		

be seen to contain the green, fluorescent pigment produced by *Pseudomonas* bacteria when the broken-out eggs were examined in ultra-violet light or daylight. Eggs that were inoculated in the narrow end or air-cell are denoted by N. E. or A. C. respectively.

Seven days after injection, the egg contents possessed the characteristic smell and taste of the defective frozen egg examined previously; perceptible mustiness was similarly associated with a positive value of $\Delta F'$, and tasting tests on the mixed white and yolk showed that a similar relation held between flavour score and $\Delta F'$ *(1)*. For example, when $\Delta F'$ was 94, the flavour score was 4. When $\Delta F'$ was in the neighbourhood of 300, the flavour score approached zero; when $\Delta F'$ was about 800 (Table 4), the musty smell was perceptible throughout the room when the eggs were broken open.

When suspensions of *Pseudomonas putida* were injected into the air-cell of a batch of fresh eggs, similar changes occurred at a slower rate; the injection of the organisms into the narrow end of the egg had little effect. It is possible that fresh eggs are more resistant to microbial attack than stored eggs but the difference between the data in Tables 2 and 3 may be caused by a variation between different batches of eggs.

The data in Table 4 were obtained from fresh eggs injected with the unidentified *Pseudomonas sp.* isolated from a cold-stored, musty egg. The results were similar to those given by *Pseudomonas putida* but it can be concluded that the unidentified strain was considerably more active in producing mustiness and increasing $\Delta F'$ since it so happened that the results shown in Tables 3 and 4 were obtained with eggs drawn from the same batch.

TABLE 3

The effect of inoculating fresh eggs with Pseudomonas putida

Days at 20° C.	N. E. eggs		A. C. eggs	
	$\Delta F'$	% green whites	$\Delta F'$	% green whites
0	0	0	0	0
4	—4	0	4	0
8	—3	0	23	0
10	—11	0	219	50
18	2	0	77	33

TABLE 4

The effect of inoculating fresh eggs with an unidentified Pseudomonas sp. isolated from a musty egg

Days at 20° C.	N. E. eggs		A. C. eggs	
	$\Delta F'$	% green whites	$\Delta F'$	% green whites
0	0	0	0	0
5	3	33	6	67
6			35	50
7	128	50	66	67
12	15	17	750	100
16	380	67		

It will be seen that in Tables 3 and 4 the value of $\Delta F'$ did not always increase with time in a regular manner, and that parallel irregularities occurred in the values for the proportion of green whites. Judging by the incidence of green whites in a given sample, and the intensity of the condition when it occurred, it can be concluded that individual eggs varied considerably in their resistance to microbial attack if it can be assumed that each egg in the sample received a similar inoculum.

Pseudomonas schuylkillensis behaved in a different manner; $\Delta F'$ increased rapidly and green pigment appeared in the white (Table 5) but none of the eggs became musty. Instead, they acquired the slightly-feculent, cabbage-water smell that commonly accompanies *Pseudomonas* infection in English eggs. A positive value of $\Delta F'$ is therefore not an exclusive property of serum from musty eggs although it may be a characteristic of eggs infected with *Pseudomonas*.

With eggs inoculated with *Pseudomonas* bacteria, the change in $\Delta F'$ followed a roughly similar pattern in all the experiments; after a lag phase of several days, $\Delta F'$ increased, irregularities apart, at an ever-increasing rate. The other common feature

TABLE 5

The effect of inoculating previously-stored eggs (3 weeks at 25° C.) with Pseudomonas schuylkillensis

Days at 20° C.	N. E. eggs		A. C. eggs	
	$\Delta F'$	% green whites	$\Delta F'$	% green whites
0	0	0	0	0
4	2	0	3	0
6	55	0	52	0
11	982	33	1234	67

* The fluorescence was measured 10-15 minutes after the addition of $Na_2S_2O_4$. The fluorescence of the serum from eggs inoculated with *Pseudomonas* bacteria tended to increase with time after the addition of $Na_2S_2O_4$, the rate of increase being greater when $(\Delta F)_i$ was large; there was little change in the first 30 minutes.

was that injection into the air-cell was more effective than injection into the narrow end of the egg in spite of the fact that organisms in the former case had to penetrate the inner shell membrane before entering the white. The difference may be a reflection of the more plentiful supply of oxygen available to the organisms in the neighbourhood of the air-cell; whatever the cause, it outweighed any delaying and bactericidal effect exerted by the inner shell membrane *(4, 7)*.

It is doubtful if any of the eggs inoculated with *Pseudomonas* bacteria would have been rejected during commercial candling except possibly a very few of the more intense green whites. Curiously enough, as shown in Figure 2, there was no consistent difference between the fluorescence of the serum from control and infected eggs before the addition of $Na_2S_2O_4$[4] (especially in comparison with the differences after the addition of $Na_2S_2O_4$) in spite of the fact that the white of the infected eggs often contained the green, fluorescent pigment produced by *Pseudomonas* bacteria. Nevertheless, this finding is in good agreement with that previously made during the examination of commercial frozen egg; namely, that there was no correlation between the intensity of mustiness and the fluorescence of the serum before the addition of $Na_2S_2O_4$.

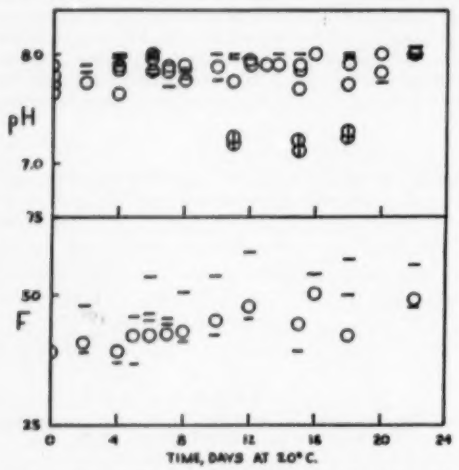

Figure 2. Changes in the pH of the mixed white and yolk, and the fluorescence of the serum of fresh eggs kept at 20° C. (68° F.). Control eggs (O); eggs inoculated with Pseudomonas bacteria (—); eggs inoculated with Aerobacter bacteria (Ⓘ).

The behaviour of Aerobacter cloacae. Suspensions of *Aerobacter cloacae* did not produce any visible pigment after injection into eggs but the white became turbid and exhibited a blue fluorescence when exposed to ultra-violet light; there was no change in the appearance or fluorescence of the white of the control eggs during the same period. The infected eggs acquired a sickly, sweetish smell and flavour; the taint was easily perceptible 8 days after inoculation and increased rapidly thereafter. The fluorescence of the clear serum (of pH 6) also increased rapidly. The addition of $Na_2S_2O_4$ caused no increase of fluorescence; instead, it quenched the fluorescence in an irregular manner. The results obtained when the suspensions were injected into the air-cell of fresh eggs are set out in Table 6; there was little difference in the rate of change when the organisms were injected into the narrow end of the egg.

Insofar as both the white and serum exhibited a blue fluorescence in ultra-violet light, there was a resemblance between an old egg, and an egg infected with *Aerobacter cloacae*. At comparable values of F, however, the turbidity of the white of infected eggs and the appearance of the vitelline membrane was sufficient, apart from the smell, to distinguish these eggs from eggs that were merely old.

[4] There was an even closer correspondence before the addition of $Na_2S_2O_4$ between the fluorescence of the serum from control and infected eggs in the experiments with eggs that had previously been stored at 25° C. (77° F.) for three weeks.

TABLE 6
The effect of injecting Aerobacter cloacae into the air-cell of fresh eggs

Eggs	Days at 20° C.				
	0	8	11	15	18
Controls F.	57	51	50	43	53
—(ΔF)c	18	6	15	14	16
A. C. eggs F.		89	115	127	185
—(ΔF)t		36	19	14	71

Effect of bacterial infection on pH. General bacterial multiplication in liquid whole egg will, if unchecked, lead to souring, and the pH may fall to 6.5 or even less. The pH of the liquid whole egg prepared from some of the samples of control and injected eggs are shown in Figure 2. As would be expected, there was a variation between the pH of different control samples but there was no evidence that *Pseudomonas* bacteria caused any appreciable change in pH. The presence of *Aerobacter cloacae*, however, seemed to lower the pH to a significant extent.

DISCUSSION

There was a close correspondence between the properties of the musty, commercial frozen egg and the liquid whole egg prepared from shell eggs inoculated with *Pseudomonas putida* or an unidentified *Pseudomonas sp.*; it seems reasonable to conclude that the defects in the commercial material were originally caused by similar species of *Pseudomonas*. In the present experiments, *Pseudomonas schuylkillensis* did not cause mustiness; Richard and Mohler *(3)* also observed that this species, although able to produce mustiness in culture media, did not always do so within the egg.

Green whites, which are usually attributed to the action of *Pseudomonas* bacteria, seem to possess two or possibly three distinct types of smell. The majority of green whites found in English cold-stored eggs smell of cabbage water; only a very small minority are musty, the mustiness being either of a damp, earthy nature (as in the present experiments) or possessing a more penetrating, mouldy character. A number of species of *Pseudomonas* have now been reported as able to cause mustiness of one sort or another in eggs: *Ps. perolens* var. *Gdansk*, *Ps. perolens*, *Ps. graveolens (5)*, *Ps. putida*, *Ps. ovalis*, *Ps. viscosa* and *Ps. schuylkillensis (3)*. It would be interesting to know the species of *Pseudomonas* that are responsible for the smell of cabbage water, and whether, on occasion, these organisms can also produce mustiness.

It is a commonplace that breakers engaged in the manufacture of frozen egg should possess a keen sense of smell. As far as mustiness is concerned, the results described above show that the appearance of the broken-out egg is a less sensitive guide than its smell. Defective frozen egg was perceptibly musty, if only barely so, to graders and bakers when $\Delta F'$ was positive and less than 20 units. It will be seen from the tables that this degree of mustiness could be present in eggs that showed no sign of bacterial pigment in the white even when the broken-out eggs were examined in ultra-violet light.

SUMMARY

Suspensions of bacteria were injected into shell eggs. With suspensions of *Pseudomonas putida* and an unidentified *Pseudomonas sp.* isolated from a musty, cold-

stored egg, the contents of the eggs became musty at an increasing rate; the increase of fluorescence when a clear serum extracted from the egg contents was treated with $Na_2S_2O_4$ under standard conditions was quantitatively related to the intensity of mustiness. *Pseudomonas schuylkillensis* caused similar changes in the fluorescent properties of eggs but did not produce mustiness; instead, there appeared the cabbage-water smell that usually accompanies infection by *Pseudomonas* bacteria. An increase of fluorescence on treatment with $Na_2S_2O_4$ is therefore not an exclusive property of the serum of musty eggs although it may be characteristic of eggs infected with *Pseudomonas* bacteria. *Aerobacter cloacae* did not produce mustiness, nor did the fluorescence of the serum increase on treatment with $Na_2S_2O_4$.

Before treatment with $Na_2S_2O_4$, the fluorescence of the serum from eggs inoculated with *Pseudomonas* bacteria was similar to that of the serum from the control eggs; *Aerobacter cloacae* caused an increase in the fluorescence of untreated serum. *Pseudomonas* bacteria had little or no effect on the pH of the mixed white and yolk of infected eggs; *Aerobacter cloacae* caused a decrease of pH. *Pseudomonas* bacteria injected into the air-cell of an egg produced more rapid changes than a similar inoculum in the narrow end of the egg; the location of the injection had little effect on the behaviour of *Aerobacter cloacae*.

The fluorescence of the serum extracted from untreated eggs depended on the age of the eggs and the temperature at which the eggs had been kept.

Acknowledgments

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Some Factors Affecting the Sodium Chloride Content of Haddock During Brine Freezing and Water Thawing[a]

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(Manuscript received April 9, 1954)

A study of the penetration of salt into fish during brine freezing was made in connection with the U. S. Fish and Wildlife Service's study of the commercial feasibility of freezing fish at sea aboard the experimental trawler Delaware. Penetration of salt was found to be influenced by the temperature, concentration, and composition of the sodium chloride brine, by the length of time the fish were immersed in the brine, and by whether the fish were gutted or ungutted. Salt penetration occurring under routine operations was found to be a minor factor, and salt was shown to be leached from the fish during water thawing. Salt content of flesh directly under the skin was shown, after water thawing, to be below the taste threshold (0.5 percent) for salt in fish.

In the course of a continuing study of the feasibility of freezing fish at sea, the Boston laboratory of the Fish and Wildlife Service has investigated immersion freezing *(7)* of the fish aboard the experimental trawler *Delaware*. The frozen fish are water thawed prior to commercial processing into fillets. Results to date with round (unEviscerated) fish indicate that this method of freezing is commercially feasible. A recent and thorough review of the study has been reported by Puncochar and Pottinger *(10)*.

In the formative stages of the freezing-at-sea project, there was some question as to whether the freezing by immersion in cold sodium chloride brines might be objectionable from the standpoint of possible excessive penetration of the salt into the flesh of the fish. Studies by various investigators *(2, 3, 6, 9, 11)* indicated that with proper procedures the amount of salt penetrating into the flesh can be controlled. Preliminary work along these lines at this laboratory confirmed these findings. Later, this laboratory initiated a detailed study of the various factors governing the penetration of salt into fish during the immersion freezing process. The study was to serve as a guide in the development of suitable procedures for the immersion freezing of certain

[a] Presented December 29, 1953, at the Convention of the American Association for the Advancement of Science, Boston, Massachusetts.
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varieties of groundfish native to the Northwestern Atlantic Ocean.

The following major factors governing the penetration of salt into flesh during immersion freezing of fish were selected from the studies conducted at this laboratory and will be reported on here: (a) brine temperature, (b) brine concentration, (c) immersion time, (d) brine composition, (e) evisceration of fish prior to freezing, (f) Salt penetration during unsupervised semicommercial operations, (g) leaching of penetrated salt during the water-thawing process.

The penetrated salt content in brine-frozen fish and in brine-frozen and water-thawed fish will be discussed in terms of taste thresholds and tolerances for salt in fish.

EXPERIMENTAL

A study of the published literature on the penetration of salt into fish during immersion freezing in sodium chloride brines indicated that sample control was of paramount importance for reproducibility of results. Replicate values of salt content, in some cases, varied by as much as 200 to 300% *(2)*. Preliminary work at this laboratory, which showed variations in replicate values of some 40 to 50%, confirmed the necessity for sample control. On the basis of this preliminary work and to fulfill the requirements for which the study was initiated, a reproducibility of ±20% was deemed necessary.

A precise and reproducible method of sampling the frozen fish was developed to meet these requirements. In the preparation of samples for determination of salt content, the heads and tails of the individual brine-frozen haddock were removed with a meat saw. The skin, relatively easily removed by hand from the frozen flesh, was discarded. The exposed flesh, from pectoral fin to tail and between the lateral lines and dorsal line to a depth of one-quarter inch, was very carefully cut from the still semi-frozen fish. A second quarter-inch layer, identical to the first, was then removed from the exposed interior flesh. Figure 1 illustrates this procedure.

Six strips of flesh, of the same depth level, from 3 fish were grouped to form one sample . The sample was then ground in a meat grinder, mixed thoroughly by hand, and reground. Two portions of the ground meat, of about 10 g. each, were removed for analyses. The salt content of 3 such samples, in good quantitative agreement in the majority of cases, was averaged to give a relatively stable, reproducible figure for salt penetration. Total salt content was determined on samples prepared from all the flesh above the lateral lines as illustrated in Figure 1. Salt determinations were made by the modified Volhard titration procedure *(1)*.

Unless the conditions of the experiment required otherwise, all brines used in the study contained 23% (by weight) sodium chloride. Such a solution is of the eutectic concentration, affording the lowest freezing point (−6° F.) that is possible with sodium chloride solutions. The total salt content of trawl-caught, gutted haddock, stored in ice, was found to range from 0.13 to 0.17%.

Brine temperature and concentration. To study the effects of brine temperature, of brine concentration, and of length of immersion periods on salt penetration, a portable immersion freezer developed at this laboratory *(8)* was used. The relatively small quantities of brine (150 pounds) used in the freezer and the ease with which the temperature of the brine could be controlled facilitated study of the different factors governing salt penetration. Round haddock of known history were frozen in brine at −6°, 0°, 5°, 10°, and 15° F., at sodium chloride concentrations of 15 and 23%. They were held in the brine for periods of time up to 24 hours.

Immersion period. The observed continuation of salt penetration into the fish throughout an immersion period of 24 hours appeared to conflict with reports from the West Coast (private communication) concerning the prolonged immersion of salmon and tuna in cold (5° F.) sodium chloride brines without undue penetration of salt into the fish. An experiment was therefore conducted to test the degree and rate of penetration of salt into fish during a 2-week immersion in cold brine. Fresh (less than 24 hours dead), carefully iced, undamaged, round haddock were chosen for the experiment. They were rinsed to remove slime and debris, and were individually tagged for sample identification. The fish were separated into groups of three, and each group

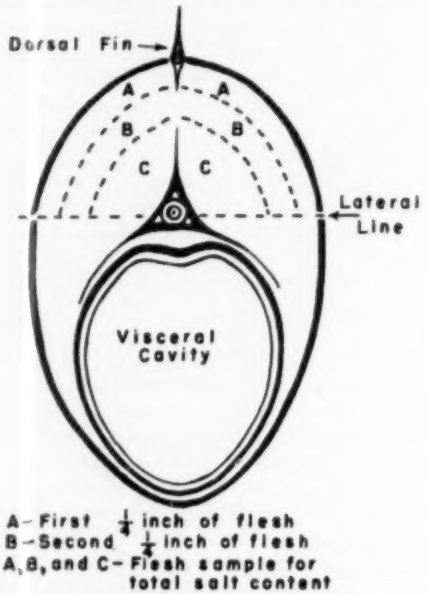

Figure 1. Cross section of haddock showing portions of flesh removed for salt analyses.

was weighed. The fish were then immersed in a cold (5° F.) sodium chloride (23%) brine. The brine was agitated by a sump pump, and the temperature was controlled by a thermostat. The usual variation in temperature was about ±1° F., with two short periods when the temperature dropped to about +2° F. A group of 3 fish was removed at the end of the first, second, fourth, sixth, eight, tenth, and twelfth day.

Upon removal from the brine, the fish comprising a particular group were washed and weighed. Each fish was cut, in cross section, at the point of maximum girth and examined for evidence of thawing due to excessive salt penetration. The extent of thawing, evidenced by a dark ring of flesh surrounding white, hard-frozen flesh, was measured. The fish were then wrapped in kraft paper to retard desiccation and stored in a cold (−20° F. ambient temperature) box. Subsequently, determinations of penetrated salt, of total salt, and of moisture changes in the flesh due to salt penetration were made.

Brine composition. Hober *(5)* reports the results of many investigations of the "solubilizing" of animal membranes by pure sodium chloride solutions and also the prevention of such action by the addition of small quantities of calcium and magnesium salts. Tressler *(13)* and Taylor *(12)* refer to similar effects of calcium and magnesium salts in retarding the rate of salt penetration during the salting of fish. In line with this work, a study was made at this laboratory of the effect of a variation in the composition of sodium chloride brine on salt penetration into immersed fish. A eutectic (23%) sodium chloride brine containing calcium chloride (1%) and potassium chloride (0.6%), essentially a fortified Ringer's solution, was cooled to 5° F. Fish were immersed and frozen for 90 minutes. Since the results appeared promising, the experiment was repeated aboard the trawler *Delaware* under semicommercial conditions at sea.

Eviscerated fish. The freezing of fish at sea aboard the *Delaware* has been performed on round fish, that is, with the viscera intact. To provide answers to possible inquiries, a study of the changes in salt content of eviscerated fish during the immersion-freezing process was made in the course of regular

semicommercial freezing operations at sea. The eviscerated fish were frozen in the brine (5° to 10° F.) for 90 minutes. Owing to the fact that salt entered from the outside surface as well as from the visceral cavity, salt gradient studies were not practical. Salt content was expressed as total salt present in particular portions of the fish, namely: (a) the full-nape fillet, (b) the quarter-nape or commercial fillet, (c) the collar, (d) the nape, (e) the tail portion, and (f) the water-thawed, full-nape fillet.

Salt content of commercially brine-frozen and of brine-frozen and water-thawed fish. Several large, random samples of haddock and of scrod haddock, frozen at sea with only superficial supervision, were removed from various lots of frozen fish before and after routine water-thawing processing. The large haddock and the scrod haddock had been immersed in the cold (5° to 8° F.) eutectic brine for 180 minutes and for 90 minutes, respectively. These immersion periods have been found to fit conveniently into the normal routine of operations aboard the trawler. The conditions of the water thawing, insofar as was practical for large quantities of fish, were standardized. Temperature of the thawing water was maintained at 60° ± 5° F. The water was agitated by means of a motor-driven propeller. The scrod were immersed in the thawing water for 120 minutes and the haddock for 200 minutes. The thawed samples were immediately refrozen in a plate freezer (—20° F., ambient temperature) to ensure that salt, remaining in the flesh, did not diffuse throughout the fish. Salt gradient studies were performed on 6 samples of 3 fish each, of both the brine-frozen (before water thawing) and brine-frozen and water-thawed scrod haddock and haddock.

RESULTS AND DISCUSSION

Brine temperature. The effect of brine temperature upon salt penetration into fish during an immersion-freezing process is shown in Table 1. A graded increase in salt content in the first quarter-inch of flesh, with increase of brine temperature, is observed. The increase in salt content of the second quarter-inch of flesh in all cases is slight and is well below the taste threshold, 0.5 to 0.6%, (unpublished data) for salt in fish. The increase in salt content in the first quarter-inch of flesh evidences serious differences only when considered in relation to freezing rates at the differing brine temperatures. Fish immersed for one hour at —6° F. are wholly frozen and absorb further salt very slowly. Those immersed for one hour at higher brine temperatures are not frozen and continue to absorb salt at a relatively high rate. It is apparent that the brine temperature, to minimize the rate of salt penetration during the initial periods of freezing, should be held as low as is feasible.

TABLE 1

Variation in salt content of the flesh of round scrod haddock immersed for one hour in sodium chloride (23%) brine at different temperatures

Brine temperature	Salt content	
	In 1st ¼ inch of flesh	In 2nd ¼ inch of flesh
° F.	*Percent*	*Percent*
—6	0.37	0.15
0	0.51	0.19
5	0.55	0.24
10	0.64	0.23
15	1.15	0.24

Brine concentration. Studies performed in this laboratory confirmed the belief that the brine concentration affects the rate at which salt penetrates into the flesh of fish during the immersion-freezing process. Scrod haddock, after a 60-minute immersion in a eutectic (23%) sodium chloride brine held at 15° F., contained 1.2% salt in the first quarter-inch of flesh. Other scrod haddock, of the same history, frozen under the same conditions in a 15% sodium chloride brine, contained 0.72% salt in the corresponding level of flesh. There were no significant differences in the salt contents of the second quarter-inch levels of flesh of the samples.

Studies of the effect of brine concentration on the penetration of salt into fish were discontinued when, to attain faster freezing rates for semi-commercial operations, it was decided to use a eutectic (23%) sodium chloride brine. As a result of the lower brine temperatures possible and the correspondingly faster freezing, the effect of brine concentration has not been a problem. All other results reported in this paper are based on the use of a eutectic brine.

Immersion time. The effect of the length of the immersion period (up to 24 hours) for fish in brines of different temperatures is shown in Table 2. During the first portion of the immersion period, there is a relatively high rate of penetration of salt. The rate of penetration tapers off as the immersion period is increased to such an extent that penetration during the second 2 hours of a 4-hour immersion period is approximately only ⅓ of that occurring in the first 2 hours. The initial higher rate continues for a longer period of time in fish frozen in the brines of higher temperatures. The relatively slow penetration, occurring after the freezing of the outer layers of fish, has been called "secondary penetration." It appears to persist throughout the immersion period. After 24 hours' immersion, the further increase in salt content due to "secondary penetration" is marked. It is greatly reduced, but not eliminated, by maintenance of lower brine temperatures. With the exception of the samples immersed for 24 hours, the increased salt content of the fish is again shown to be concentrated in the first quarter-inch of flesh. After immersion for 24 hours, there is a noticeable increase in the salt content of the second quarter-inch of flesh.

TABLE 2

Variation in salt content of flesh of round scrod haddock immersed in sodium chloride (23%) brine for differing times and at differing temperatures

Immersion time	Salt content					
	5° F.		10° F.		15° F.	
	1st ¼ inch of flesh	2nd ¼ inch of flesh	1st ¼ inch of flesh	2nd ¼ inch of flesh	1st ¼ inch of flesh	2nd ¼ inch of flesh
Hours	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
1	0.55	0.24	0.64	0.23	1.15	0.24
2	0.91	0.31	1.10	0.26	1.27	0.26
4	1.22	0.20	1.29	0.24	1.49	0.21
24	2.09	0.84	3.02	0.93	5.15	3.01

The results of the tests of salt penetration into fish immersed in cold (5° F.) brine for prolonged periods (up to 12 days) are shown in Tables 3 and 4. Table 3 shows the thawing (due to increased salt content) which reached a readily measurable depth after 48 hours and reached a depth of $^{9}/_{32}$ of an inch after the fish were immersed for 12 days. The corresponding increase in total salt content of the fish from 1.01% after being immersed in the brine for 1 day to 10.1% after 12 days' immersion is also shown. The high weight change, occurring in the 10-day immersion group, is not yet

explainable. These figures, together with the initial weights of the various groups, are added to indicate the reason for the high total salt contents observed for the 6- and 10- day immersion groups. Thawing due to salt penetration was first noticeable as a very slight softening

TABLE 3
Effect of prolonged immersion of round scrod haddock in sodium chloride (23%) brine at 5° F.

Immersion time	Initial weight of fish	Weight loss	Depth of thaw in flesh	Total salt content [1]
Days	*Grams*	*Percent*	*Inches*	*Percent*
1	2320	0.8	0	1.01
2	2330	1.7	1/32	2.22
4	2635	1.7	3/32	4.68
6	2215	3.1	5/32	7.40
8	2430	1.9	7/32	6.21
10	1845	8.1 [2]	9/32	10.6
12	2050	1.7	9/32	10.1

[1] Of all flesh above the lateral lines of the fish.
[2] The high weight loss in this group of fish is as yet unexplained.

TABLE 4
Variation in moisture and salt content of flesh of round scrod haddock immersed in cold (5° F.) sodium chloride (23%) brine for extended periods

Immersion period	Moisture content		Salt content	
	1st ¼ inch of flesh	2nd ¼ inch of flesh	1st ¼ inch of flesh	2nd ¼ inch of flesh
Days	*Percent*	*Percent*	*Percent*	*Percent*
2	76.8	80.6	4.48	1.39
4	74.5	77.7	5.81	3.57
6	73.6	75.5	7.51	5.64
10	71.8	70.8	10.3	8.98
12	69.4	69.7	12.3	10.7

of the skin of the fish. As salt continued to penetrate into the frozen flesh, thawing occurred at greater depths. Shrinkage, due apparently to loss of water from the fish, began after 48 hours and eventually became so great as to cause outlines of the muscular striations to appear on the skin. After 4 days, the tail section became pliable; this condition spread slowly to about ⅓ the length of the fish at the time the test was terminated. Upon examination of the cut cross-sectional surfaces, two sharply demarked areas were observed. Centers were hard frozen and white, but surrounding the hard-frozen areas were bands of soft, highly discolored unfrozen flesh.

Table 4 shows the increase in penetrated salt in the first and second quarter-inch levels of flesh during the prolonged immersion test. The corresponding changes in the moisture content of the 2 levels of flesh are also tabulated. After 2 days' immersion, when thawing was first observed, the salt content of the first and second quarter-inch levels was 4.5 and 1.4%, respectively. On the twelfth day of the tests, the salt in the corresponding levels of the test fish had risen to 12.3 and 10.7%, respectively. The characteristic smoothing out of the salt gradient as thawing continues is borne out by the changes in moisture content in the 2 levels of the fish during the test. After 2 days, the moisture content of the first and second quarter-inch levels was 76.8 and 80.6%, respectively. After 12 days' immersion, the moisture content of the corresponding levels was 69.4 and 69.7%.

These studies indicate that the penetration of salt into non-fatty groundfish (haddock) of the northwest Atlantic continues throughout the period of immersion in brine. The work of Godsil *(3)* and of Lang and Farber *(6)* on salt penetration into tuna during prolonged immersion in cold brines indicates that such secondary penetration is very much slower in these fish. Godsil found that when tuna were immersed in brine at 20° F., 34 days' immersion was required before the salt struck through the first 1¼ inches of flesh. Lang and his coworkers found only 7 to 8% salt in the first quarter-inch of flesh of tuna after immersion in cold (5° F.) brine for almost 2 months. Subsequent to the performance of this laboratory's work, a progress report by Harrison and Roach *(4)* on brine freezing of fish was received. These investigators found no change in the sodium chloride content of the flesh of 2 types of fatty fish (king salmon and chum salmon) during brine freezing, whereas grey cod, similar in composition to cod and haddock found in the Atlantic Ocean, showed a distinct increase in salt content. Thus, there appears to exist a distinct difference in the permeability of the flesh of brine-frozen fatty fish of the Pacific Ocean and that of the non-fatty groundfish of the Atlantic Ocean.

Brine composition. Table 5 shows the effect of a modified sodium chloride brine upon salt penetration into the immersed fish. In the laboratory tests and

TABLE 5
Variation in salt content of flesh of round scrod haddock immersed for 1½ hours in sodium chloride (23%) brine (5° F.) or in a modified [1] sodium chloride (23%) brine

Replicate	Salt content			
	Sodium chloride brine		Modified sodium chloride brine	
	1st ¼ inch of flesh	2nd ¼ inch of flesh	1st ¼ inch of flesh	2nd ¼ inch of flesh
Number	*Percent*	*Percent*	*Percent*	*Percent*
Iced round fish frozen in the laboratory [2]				
1	0.73	0.23	0.46	0.16
2	0.77	0.21	0.47	0.17
Frozen at sea under semicommercial conditions [2]				
1	1.13	0.32	0.88	0.13
2	1.21	0.26	0.92	0.19

[1] Modified brine contains sodium chloride (23%), calcium chloride (1.0%), and potassium chloride (0.6%).
[2] The penetration of salt into iced fish frozen in the laboratory was, in all cases, less than that occurring under semicommercial conditions at sea.

under actual full scale semicommercial operations at sea, the salt penetration in the first quarter-inch of flesh of fish frozen in such a brine was reduced by from 25 to 33% below that of fish frozen in the usual eutectic sodium chloride brine. No salt penetrated into the second quarter-inch of flesh. These results seem to indicate that penetration is, in part, a diffusion process that may be minimized by the use of calcium salts in sodium chloride brines.

Eviscerated fish. Salt contents of the various portions of brine-frozen eviscerated fish are shown in Figure 2. These studies indicate that, with the exception of the nape, the penetration of salt into these portions of fish is not excessive. At the most, it is within the range of greatest palatability for added salt in fish (unpublished data obtained at this laboratory). The quarter-nape or commercial fillet cut, which does not include the nape, contains, prior to water thawing, a

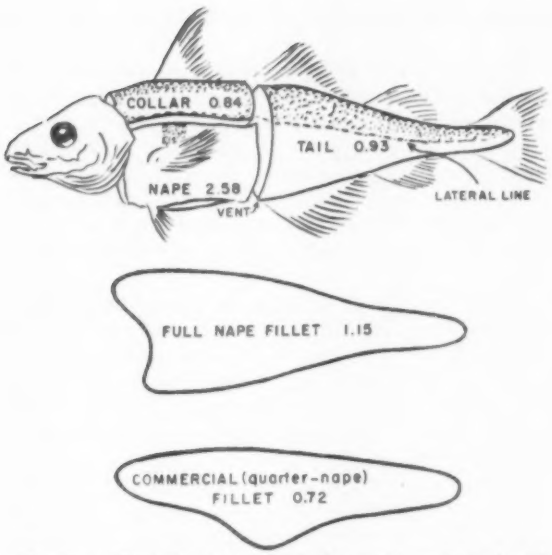

Figure 2. Variation in total salt (percent) content of various portions of eviscerated scrod haddock immersed in cold (5° F.) sodium chloride (23%) brine for ninety minutes.

total salt content of 0.72%. Such a salt content is well below that of the optimum salt level for palatability of brined fillets. From the standpoint of salt uptake, it would appear that, if adequate supervision of immersion time and brine temperature are exercised, eviscerated fish could be commercially frozen in brine.

Salt content of commercially frozen fish. Large scale analyses were performed on random samples of scrod haddock and haddock frozen at sea during different voyages of the experimental trawler *Delaware*. The results of those analyses for salt penetration during freezing are shown in Table 6. In all cases, the penetration of salt was greater than that found in fish frozen under

TABLE 6

Variation in the salt content of replicate random samples of haddock and scrod haddock frozen at sea in cold (5° to 8° F.) sodium chloride (23%) brine under semicommercial conditions

Replicate sample	Salt content			
	Large haddock [1]		Scrod haddock [2]	
	1st ¼ inch of flesh	2nd ¼ inch of flesh	1st ¼ inch of flesh	2nd ¼ inch of flesh
Number	*Percent*	*Percent*	*Percent*	*Percent*
1	1.39	0.25	1.02	0.24
2	1.19	0.27	1.06	0.22
3	1.26	0.21	1.02	0.21
4	1.61	0.18	1.12	0.17
5	1.49	0.23	1.15	0.18
6	1.67	0.20	1.05	0.22
Average	1.4	0.22	1.1	0.21

[1] Large haddock were immersed in the brine for 180 minutes.
[2] Scrod haddock were immersed in the brine for 90 minutes.

comparable conditions in the laboratory. Attempts are being made to determine the reasons for this difference. Good agreement between samples is observed. The average salt content of 6 samples (each sample composed of 3 fish) of scrod and of haddock in the first quarter-inch are 1.1 and 1.4%, respectively. Variations in the individual samples are within 20%. The major penetration is confined to within the first quarter-inch, and that in the second quarter-inch is negligible. The tapering-off of the rate of penetration is again evidenced since large haddock, immersed for twice the time of the scrod haddock, averaged only three-tenths of 1% more salt in the first quarter-inch of flesh.

Leaching of salt during water thawing. The random samples of brine-frozen and water-thawed scrod and large haddock had salt contents as shown in Table 7.

TABLE 7

Variation in salt content in flesh of replicate random samples of haddock and scrod haddock thawed (200 and 120 minutes, respectively) in water at 60° F. after being brine-frozen [1] at sea

Replicate sample	Salt content			
	Large haddock		Scrod haddock	
	1st ¼ inch of flesh	2nd ¼ inch of flesh	1st ¼ inch of flesh	2nd ¼ inch of flesh
Number	*Percent*	*Percent*	*Percent*	*Percent*
1	0.41	0.19	0.36	0.20
2	0.38	0.20	0.36	0.18
3	0.38	0.25	0.33	0.22
4	0.36	0.18	0.25	0.21
5	0.35	0.19	0.34	0.24
6	0.68	0.17	0.29	0.18
Average	0.43	0.19	0.32	0.21

[1] Haddock and scrod haddock were frozen in brine at 5° to 8° F. for 180 and 90 minutes, respectively.

It is evident that a great proportion of the salt is leached from the flesh during the thawing process. The slightly greater salt content of large haddock occasioned by the longer immersion periods necessary for freezing appears to be largely eliminated by leaching during the necessarily longer thawing period. In all samples, in the case of both scrod haddock and large haddock, the salt content has been reduced to a value only slightly greater than that of the normal unfrozen fish.

Concurrent work by this laboratory on salt uptake by haddock fillets during commercial brining prior to freezing included studies on palatabilities of and tolerances for differing levels of concentration of salt in the fillet. The work will be made the subject of another report but can be applied to studies of brine penetration to relate the observed salt contents to known tolerances for salt. Figure 1 shows a cross section of haddock at the point of maximum girth. The portions of the fish removed for sampling are indicated by the letters A (the first quarter-inch of flesh) and B (the second quarter-inch of flesh). The lateral and dorsal lines limiting the sample width are indicated. Table 8 indicates the salt

TABLE 8

Salt content of brine-frozen and water-thawed haddock and scrod haddock expressed in both percent and percent of optimum salt content for palatability [1]

Sample	Salt content			
	Brine-frozen		Brine frozen and water-thawed	
	Percent	*Percent of optimum palatability*	*Percent*	*Percent of optimum palatability*
Haddock:				
1st ¼ inch of flesh	1.4	127	0.43	39
2nd ¼ inch of flesh	0.22	20	0.19	17
Scrod haddock:				
1st ¼ inch of flesh	1.1	100	0.32	29
2nd ¼ inch of flesh	0.21	19	0.21	19

[1] The percent of optimum palatability is based on the optimum salinity (1.1%) as found by experiment. Those values which are below 50% of optimum palatability are below the taste threshold for salt in fish.

content to be expected in these portions of brine-frozen haddock and scrod haddock, and also the salt content after water thawing. Since tests at this laboratory indicate a salt content of from 0.9 to 1.2% in the fillet to be optimum for palatability, the salt content of the first and second quarter-inch levels of the commercially brine-frozen and also of the water-thawed fish is indicated in terms of percent of this optimum concentration. The salt content of the first quarter-inch of flesh of fish, frozen for 3 hours, is seen to be slightly above the optimum. That of the scrod haddock is in the optimum range. In both cases, the second quarter-inch of flesh is bland and "flat" to taste. The salt content of the first quarter-inch of flesh of both haddock and scrod haddock, after adequate water thawing, is reduced to a concentration below that discernible by the palate. The fillets prepared from such fish are bland and "flat" to the taste. It is probable that, contrary to reports of possibly excessive saltiness, fillets prepared from brine-frozen and subsequently water-thawed fish would require, to attain desirable saline palatability, to be dipped in light brines.

CONCLUSIONS

Salt penetration into the flesh of fish during immersion freezing varies directly with the temperature of the brine. The increased penetration reaches serious proportions from the standpoint of palatability when the brine temperature is 15° F. or above. For this reason and because of the increased penetration observed under commercial freezing conditions, it is recommended that temperature of a sodium chloride (23%) brine be maintained at or preferably below 10° F. when freezing fish.

Immersion of the fish for periods of time longer than is required for freezing causes an unnecessarily excessive penetration of salt. The initial penetration is rapid until the outer layers of flesh have been frozen. The rate of penetration then tapers off but continues slowly throughout the immersion period. This "secondary penetration" is greatly reduced but not eliminated by maintenance of the lowest feasible brine temperatures. Contrary to results observed by other investigators with brine-frozen fatty fish, prolonged immersion of haddock, a non-fatty groundfish, causes it to thaw as a result of excessive penetration of salt. The two closely interrelated factors of brine temperature and immersion time govern, in the main, the penetration of salt into the flesh. For these reasons, it is recommended that immersion times be restricted to 4 hours or less, if possible.

An increase in brine concentration causes a proportional increase in the penetration of salt into fish during the freezing process. This laboratory, thus far, has standardized, for semicommercial operations, on a eutectic (23%) sodium chloride brine. As a result of the lower freezing temperatures and faster freezing rates possible through use of such brines, the effect of brine concentration upon salt penetration has not been a problem.

The addition of small quantities of calcium (1%) and of potassium (0.6%) salts to a sodium chloride brine retards the penetration of salt into the fish frozen in such a brine. Salt content in the first quarter-inch of flesh of fish frozen in the "modified" brine is 25 to 33% lower than in control fish frozen in the usual sodium chloride brine.

The salt content of commercial fillets prepared from fish that were eviscerated prior to brine freezing is below the range of optimum palatability for salt (0.9 to 1.2%). Further, water thawing of the fish prior to filleting reduces the salt content to a level below the taste threshold for salt (0.5 to 0.6%) in fish. Excessive salt penetration occurred only in the nape of the fish, a portion which is not normally incorporated into the commercial fillet.

The salt gradient analyses of random samples of fish, though drawn from lots frozen during different voyages of the *Delaware*, indicate that, under normal operating conditions, differences in the content of penetrated salt are not large. After water thawing of the fish, the salt content is reduced to a level which is usually below the taste threshold for salt in fish.

The analyses further show that excessive penetration did not occur in routine freezing operations. The penetration of salt in scrod haddock and large haddock has been shown to be restricted almost wholly to the first quarter-inch of flesh during freezing under semicommercial conditions. It has further been shown that the penetrated salt is leached during water thawing to such an extent as to bring about a bland or "flat" taste to the final product.

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Varietal Differences in Cucumbers for Pickling[a,b]

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(Manuscript received May 1, 1954)

The suitability of 19 varieties and strains of cucumbers for salt-stock production were evaluated over a 3-year period at a commercial pickling plant. Differences of a magnitude considered commercially important are reported.

The acreage of cucumbers grown for pickle manufacture is fourth largest of the national truck crops grown for processing. About one-half of this crop is produced in Michigan and Wisconsin, one-fifth in the South Atlantic states and the remaining 30% in 16 other states. The wide geographical distribution of the commercial production of cucumbers for pickling has in part been responsible for the development and planting of a number of varieties. Furthermore, the greatly differing nature of pickles manufactured has favored the growing of many different varieties of cucumbers. At present about 20% of the total crop is utilized in the manufacture of "fresh" or "uncured" stock which is packed from the fresh state and is pasteurized in suitable spiced brines or light syrups for preservation. The remaining 80% of the total crop is brined at time of harvest, cured by fermentation, and held until needed for further processing and manufacture into finished pickle products.

The suitability of cucumbers for use in pickle manufacture is greatly influenced by physical and chemical characteristics which may differ decidedly between varieties or even between strains within varieties. Color and shape, characteristics which the commercial pickle maker considers to be highly important, vary widely *(3)*. Similarly, the principal deteriorative changes encountered during brine curing and storage of cucumbers have been reported to be influenced to a considerable degree by variety of cucumber *(3)*.[e] These deteriorative changes, namely softening of salt-stock and development of hollow cucumbers (bloaters), cause serious economic loss annually. The details of softening of salt-stock caused by enzymatic changes and of bloater formation, which is associated with a gaseous fermentation, have been discussed elsewhere *(1, 2, 4, 5)*.

EXPERIMENTAL

The studies reported here were conducted in cooperation with the Brown-Miller Pickle Company at their Texarkana, Texas, plant. The cucumbers tested were grown during the 3-year period 1949 to 1951 at the Fruit and Truck Branch Experiment Station, Hope, Arkansas. All test plots were harvested according to commercial practice. The yields from the different plots were determined according to size and quality grade at each picking. Forty to 50-pound lots of green cucumbers harvested from each plot were separately bagged in coded mesh bags at 2 or 3 picking dates during each season and were brined for salt-stock production. This was accomplished by placing the bags of cucumbers for the given harvest in a large vat otherwise filled with cucumbers of the variety being used at the commercial plant and which were harvested at the same date. The dates selected represented early-, mid-, or late-season pickings. Brining practices employed with vats containing the experimental material were those used by the pickle plant.

Evaluation of the brine-cured stock was made from 4 to 6 months after brining was started. Observations were made which included the following: (a) firmness of the salt-stock as measured by the U. S. Department of Agriculture fruit pressure tester, (b) the length of each sample pressure tested, (c) estimation of bloater formation as shown by inspection of longitudinally cut cucumber samples and (d) the commercial acceptability of the salt-stock as rated by judges who were plant operators.

The salt-stock was evaluated for commercial use by the judges at the time the bagged experimental lots were removed from the vats. The sample lots were then sorted to separate nubby stock. The uniform cucumbers were graded into 3 sizes based on the following diameter ranges: No. 1's, 1″ to 1⅛″; No. 2's, 1⅛″ to 1¼″; and No. 3's, 1¼″ to 2″.

The No. 1 and 2 salt-stock were used for firmness tests and length measurements and the No. 3 size stock was used to determine bloater formation.

RESULTS

Nineteen varieties and strains were tested for one or more years in this study. Harvest dates of these varieties and strains and seed source for the same are given in Table 1.

A summarization of salt-stock firmness for the years 1949, 1950 and 1951 is shown in Table 2. The firmness values shown represent the means (reported in terms of size No. 1) for 10 brine-cured cucumbers each of the number 1 and 2 sizes representing a total of 20 cucumbers. Testing was accomplished by making a single puncture with the tester at the center of each cucumber. Twelve varieties shown in Table 2 were grown in both the 1950 and 1951 seasons. The values for these 12 varieties represent a 2-year average of firmness for the stock tested.

The averaging of yearly values was done for the following reason: although the absolute value for salt-stock firmness for a given variety differed slightly from year to year the relative firmness of the different varieties tested remained about the same over the period of observation.

Included also in Table 2 are firmness means for varieties grown during one or more of the years 1949, 1950 and 1951 but not during both 1950 and 1951 seasons. All means have been adjusted for comparison to means of 3 pickings in 1950-51. The varietal firmness values in Table 2 have been organized into 3 groups the means of which differ significantly at the 5% level. Differences within each group are not significant.

The bloater formation data are presented in Table 3. Estimation of varietal differences with respect to bloater formation was based on the inspection of approximately 20 No. 3 size fruits per variety for each picking. The cucumbers were cut longitudinally and the extent and nature of bloater formation was noted. Bloater formation has been expressed in terms of percentage of the total number of cucumbers inspected for each variety.

A comparison of length of salt-stock made from different variety cucumbers is given in Table 4. These values are aver-

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[b] Presented at the Thirteenth Annual Meeting of the Institute of Food Technologists, Boston, Mass., June 23, 1953.

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[e] See also Circular No. 114, Agr. Exp. Station of the Alabama Polytechnic Institute, entitled "Studies with Pickling Cucumbers in Alabama" by Ware, Isbell, Harris and Johnson. This circular, which has been published since this paper was prepared reports marked varietal differences in suitability of cucumbers for pickling.

ages over 3 pickings in each of 2 years (1950-51). Figures are given for each size class.

The evaluation of salt-stock by judges who were pickle plant operators is summarized in Table 5. The ratings and opinions of the judges were based primarily on the appearance of the different lots of salt-stock. Color, shape and assortment of sizes in the entire sample representing each variety at each picking were the principal factors influencing the judges' decisions. Salt-stock quality as indicated by firmness and bloater percentage was not determined by the plant operator judges and was not known by these judges at the time their evaluation of salt-stock appearance was made.

TABLE 1

Cucumber varieties and strains tested. Seed source, cucumber type and years of production as indicated

Variety name and type [1]		Seed source	Year of test [2]		
			1949	1950	1951
National (LR)	b.s.	L. H. Robinson	X	X	X
National (Asgr.)	b.s.	Associated Seed Growers	X	X	X
National (NK)	b.s.	Northrup King	X	X	X
Davis Blend (LR)	b.s.	L. H. Robinson	X	X	X
Davis Blend (FHW)	b.s.	F. H. Woodruff	X	X	X
Davis Blend (NK)	b.s.	Northrup King	X	X	X
Magnolia	b.s.	Miss. Exp. Sta.	X	X	X
Model	w.s.	Associated Seed Growers	X	X	X
Packer	b.s.	Associated Seed Growers	X	X	X
Mincu	w.s.	L. H. Robinson	X	....	....
Robin 40	w.s.	L. H. Robinson	X	....	....
Snow's Perfection	b.s.	L. H. Robinson	X	....	....
Producer	w.s.	Associated Seed Growers	X	....	X
Earliest of All	w.s.	Burrell	....	X	X
Westerfield	b.s. [3]	Northrup King	....	X	X
New York	w.s. [4]	Associated Seed Growers	....	X	X
Davis Blend (SD)	b.s.	Squire Dingee	....	X	....
Yorkstate	b.s.	L. H. Robinson	....	X	....
Ohio MR-17	b.s.	Associated Seed Growers	....	....	X

[1] Varieties designated as b.s. for black spined and w.s. for white spined types. Capital letters in parentheses following variety represent abbreviation for seed source when variety from more than one source has been tested.

[2] Harvest dates as follows: 1949—June 22, July 4; 1950—June 17, July 3 and 10; 1951—June 27, July 7 and 16.

[3] Also known as Chicago Pickling.

[4] Also known as Brice Special.

TABLE 2

Varietal differences with respect to salt-stock firmness

Group I [1]		Group II [1]		Group III [1]	
Variety	P. T. [2]	Variety	P. T. [2]	Variety	P. T. [2]
Ohio MR-17	17.35 [4]	Davis Blend (NK)	15.80	Producer	14.05 [4]
Model	17.10	Yorkstate	15.75 [4]	Snow's Perf.	14.05 [4]
Packer	16.78	National (NK)	15.38	Robin 40	13.75 [4]
Earliest of All	16.78	Davis Blend (FHW)	15.26	Mincu	12.75 [4]
New York	16.35	National (LR)	15.20		
		Westerfield	15.10		
		National (Asgr.)	14.94		
		Davis Blend (LR)	14.85		
		Davis Blend (SD)	14.53 [4]		
		Magnolia	14.52		
Mean	16.67 [3]	Mean	15.17 [3]	Mean	13.65 [4]

Standard error = 0.282 5% Significant difference = 0.887

[1] Groups differ significantly at 5% level. Differences within groups are not significant. All means are adjusted for comparison to means of three pickings in 1950 and 1951.

[2] Firmness in pounds resistance to 5/16" tip of USDA fruit pressure tester. Values represent means of center readings of 10 cucumbers each of sizes No. 1 and 2 for two years of observation adjusted for reporting as size No. 1.

[3] Means in Groups I and II are those for varieties grown in both 1950 and 1951 (unmarked values) which form the basis of the grouping. Standard error and 5% significant differences for varieties grown in both 1950 and 1951 are 0.282 and 0.887, respectively.

[4] Values for varieties grown other than in both 1950 and 1951 but adjusted to these years for comparison. Standard error for these varieties, approximately 0.50.

DISCUSSION

Practical application may be made of the firmness values presented in Table 2. Based on a report made previously *(3)* salt-stock averaging 18 pounds resistance to the pressure tests or better is considered good, that averaging between 14 and 18 good to fair and that yielding an average value of 10 to 14 may be considered only poor to fair. These ranges are intended for application to stock of No. 2 size tested under the conditions outlined in the study reported here.

An adjustment in the firmness values in Table 2 should be made in order that they may be comparable to those of No. 2 stock. Analysis of the Nos. 1 and 2 size cucumbers in this study demonstrates that the size No. 2 fruit is always firmer than size No. 1 fruit in lots considered to be free from enzymatic softening. The difference in the pressure test values between Nos. 1 and 2 size fruits is approximately 1.7 pounds on the pressure tester scale. Therefore, to adjust the values in Table 2 for comparison with size No. 2 fruits it would be necessary to increase the listed values by this difference or 1.7 pounds. Upon making this adjustment it will be seen that all lots of salt-stock observed in the 3 years 1949 to 1951 may be classed either as *good* or *fair to good*. However, those varieties listed in Group III of Table 2 certainly are definitely less firm than those in the other groups and lie only slightly above the value denoting *fair* quality.

The averages in Table 4 represent an attempt to show up differences in shape as indicated by length among the

TABLE 3

Varietal differences in cucumber salt-stock for commercial use. Summary of results on bloater formation [1]

Variety	Bloaters %	Variety	Bloaters %
Group I [2]		Group II [2]	
Packer	1	Producer	12
Model	2	Magnolia	13
Yorkstate	2	National (NK)	14
New York	5	National (LR)	14
Earliest of All	5	Westerfield	14
Davis Blend (FHW)	6		
Davis Blend (LR)	6	Group III [3]	
Davis Blend (SD)	7	National (Asgr.)	29
Davis Blend (NK)	7		
Ohio MR-17	7	Group IV [3]	
		Mincu	48
		Robin 40	74

[1] Bloaters in large sized salt-stock (1⅜"-2" diam.).

[2] Groups differ significantly at the 5% level. Differences within groups are not significant. All percentage values are adjusted for comparison to means of 3 pickings in 1950 and 1951.

[3] Varieties in this group grown in 1949 only. Percentage values not adjusted for comparison to means of 3 pickings in 1950 and 1951.

TABLE 4

Average length of salt-stock made from different cucumber varieties [1]

Variety	Size		Judges' comments on length where applicable
	No. 1	No. 2	
	Inches	*Inches*	
National (NK)	2.58	3.79	Blunt
Producer	2.69	3.69	Stubby, pecan-shaped
Packer	2.87	3.91	Blunt
National (LR)	2.87	3.97	Blunt
Model	2.94	3.84	Too blocky in shape
Davis Blend (FHW)	3.03	3.97	Blunt
National (Asgr.)	3.04	4.06	Blunt
Davis Blend (LR)	3.11	4.11	Blunt
Westerfield	3.15	4.05	Blunt
Davis Blend (NK)	3.23	4.40	No comment (satisfactory)
Magnolia	3.25	4.29	No comment (satisfactory)
Earliest of All	3.37	4.38	No comment (satisfactory)
Ohio MR-17	3.48	4.80	No comment (satisfactory)
New York	3.80	4.92	Too long

[1] Values are averages of ten cucumbers from each of three pickings from each of the two years 1950 and 1951.

TABLE 5

Varietal differences in cucumber salt-stock for commercial use: summary of judges' evaluation (1949-1951)

Variety and grouping	Percentage of salt-stock ratings by judges as:			Judges' criticisms of less desirable varieties
	Acceptable	Barely Acceptable	Not Acceptable	
I Good				
Davis Blend (NK)	100	0	0	Acceptable at all pickings by all judges.
Yorkstate	100	0	0	
Davis Blend (SD)	100	0	0	
Ohio MR-17	100	0	0	
II Fair				
Earliest of All	90	10	0	Pointed; nubby
Westerfield	90	10	0	Color too light; blunt; nubby.
Packer	80	20	0	Blunt
Davis Blend (FHW)	80	20	0	Color too light; blunt; nubby.
Davis Blend (LR)	70	30	0	Color too light; blunt; nubby.
National (Asgr.)	60	40	0	Color too light; blunt; nubby.
National (NK)	60	40	0	Color too light; blunt; nubby.
Model	50	50	0	Too blocky in shape.
Snow's Perfection	50	50	0	Too blocky in shape.
III Poor				
Magnolia	50	30	20	Irregular shape; pointed, crooked.
National (LR)	50	30	20	Color too light; blunt; nubby.
IV Not acceptable				
Producer	10	50	40	Stubby; pecan-shaped; soft seed cavity.
New York	0	30	70	Color too dark; too long; too pointed.
Mincu	0	0	100	(As for Producer)
Robin 40	0	0	100	Color too dark, slender, skin smooth.

varieties. Judges' comments on length are placed alongside the varieties indicating some agreement that salt-stock measuring approximately 3⅛″ to 3½″ in the No. 1 size is more desirable for plant use.

A detailed analysis of the length measurements indicate that the differences among varieties behaved consistently over the 2 years and among the several pickings. Observations made but not reported here indicated that the cucumbers get slightly shorter as the season progresses and that the 1950 season produced slightly longer cucumbers than did the 1951 season.

A comparison of Table 2, 3, and 5 involving quality evaluation by distinctly unrelated technics places the different varieties and strains in approximately the same rank order. A striking relationship brought out by this study and repeatedly indicated in the different tables is the decided difference in quality or acceptability for commercial use of the different strains of a single variety. Actually, the range of quality ranking is nearly as large between strains (as represented by different seed sources) of a given variety as between varieties.

It should be recognized that the choice of the variety or strain of pickling cucumber to be grown for, or purchased by, pickle manufacturing plants is influenced by factors other than those affecting salt-stock quality. These other factors, which are obviously very important, include productivity and uses for the green cucumbers other than for brining. Productivity is greatly influenced by plant and fruit resistance to disease and other genetic characteristics. Non-brining use of the crop involves mainly the utilization of portions of the harvests for pasteurized "fresh" pickle packs. As was pointed out earlier, about one-fifth of the pickling cucumber crop is used for such "fresh-pack" products. Consideration of these other factors has not been included in this report. Therefore, it is not possible to point out the most acceptable variety or strain for use by commercial pickle packers. However, a number of conclusions are drawn from this study and are listed below as follows:

(a) Model, Packer, Earliest of All, and Ohio MR-17[1] are varieties which were found to be most satisfactory for salt-stock production.

(b) The variety Producer was not a good one from the pickle manufacturer's viewpoint because it favored formation of salt-stock which was low in firmness, poor in shape and color, and was rather high in percentage of bloaters formed during curing.

(c) Mincu and Robin 40 per unsuitable for brining due to poor shape, low firmness and high bloater content.

(d) Several strains of the National variety were classified as from fair to poor under the conditions of this test. Cucumber color in these strains was frequently light, the shape was blunt in the larger sizes and bloater formation was excessive.

(e) New York (Brice Special) was unacceptable for salt-stock production because of excessive length and because it was too dark in color.

SUMMARY

An evaluation of the suitability of 19 varieties and strains of cucumbers for salt-stock production during a 3-year period has been made at a commercial pickling plant.

Consistent differences of a magnitude believed to be commercially important were observed in the experimental lots tested for salt-stock firmness and bloater content.

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[1] Ohio MR-17 has been only recently introduced and experience with this variety was more limited than with most of the other varieties or strains tested.

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Factors Influencing the Quality and Texture of Frozen Cultivated Blueberries[a,b]

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The effect of various packing media — water, sucrose syrups, and "dry" sugar—on the textural characteristics of frozen commercially cultivated blueberries is reported. Subjective and objective valuations were made and, based on the results, thawed blueberries are classified in three groups in the order of increasing firmness.

Inasmuch as the commercial production of cultivated blueberries is increasing, and as a greater percentage of the crop not sold as fresh berries is being frozen, a study of certain factors influencing the acceptability of frozen blueberries appears warranted. This investigation was primarily concerned with the effect of various packing media, such as water, sucrose sirups, and "dry" sugar on the textural characteristics of frozen commercially cultivated blueberries that have been stored for various times at 0° F. (—17.8° C.).

Review of literature. A review of the literature on frozen blueberries reveals considerable disagreement. Whether dry sugar packs or sirup packs are to be preferred is still a subject of much discussion. In addition, the question of whether or not blanching in steam or hot sucrose sirup prior to freezing is necessary to prevent off-flavor or the development of an undesirable texture is also discussed both pro and con.

In an early study on freezing cultivated blueberries, Moon, Smart, and Caldwell *(11)* packed 5 varieties of berries (Cabot, Pioneer, Concord, Rubel, and Rancocas) with (a) various concentrations of sucrose sirups, (b) with dry sugar, and (c) without sugar or sirup. After freezing and storage for 7 to 18 months at 15° F., the authors preferred for both flavor and appearance the 50° sirup pack to the other sirup packs as well as to the dry sugar packs. In turn, the dry sugar packs were rated superior to the fruit frozen without added sugar.

Frewer, Levcowich, Skinner, and Davis *(4)* observed that blueberries frozen with sugar retained more ascorbic acid than those frozen without sugar.

If frozen blueberries were to be used for cooking purposes, Winter *(15)* stated that a dry pack could be used. However, if the blueberries were to be used for dessert, sirup packs were recommended. Similarly, Martin *(9)* reported that blueberries frozen in a 30% sugar sirup were superior in flavor and texture to those frozen with dry sugar or with no sugar at all.

Woodruff and Atkinson *(16)* advocated, as a prefreezing treatment, blanching blueberries to an internal temperature of 185 to 190° F. in order to prevent the fruit from becoming "seedy" or "woody" when held more than 6 months in storage at 0° F. The woodiness that developed was attributed to enzymatic action as well as to a toughening effect of the sugar or sugar sirups. Thawed unblanched blueberries that had been frozen for one year, and in which woodiness had developed, were not improved in flavor or texture by cooking for 10 minutes.

In a comparison of both blanched and unblanched frozen blueberries that had been stored up to 8 months at 0° F. and packed with 40° sucrose sirups, with dry sugar, and with no added sugar or sirup, Kirkpatrick *(8)* observed that the unscalded berries retained more of their original fresh flavor and characteristic firmness. The skins of the unscalded blueberries were, however, judged to be slighdy more tender. Blueberries packed in either dry sugar or sirup were superior in all respects to those packed without any sugar, inasmuch as off-flavors developed in the latter within 4 months of storage.

Selection of tender-skinned varieties of blueberries and blanching in steam for one minute before freezing improves the texture of blueberry skins as well as their over all quality according to Matlack *(10)*

[a] Contribution No. 948 Massachusetts Agricultural Experiment Station, U. of Mass., Amherst, Mass.

[b] Presented at the Fourteenth Annual Meeting of the IFT, Los Angeles, California, June 27, 1954.

Tressler and Evers *(14)* stated that although some varieties yield a frozen product with tough skins, most blueberries freeze well. They were also of the opinion that by slightly crushing the berries and mixing with dry sugar in the ratio of 5 or 6 pounds of fruit to one pound of sugar, a much better product resulted than when the berries were frozen dry with no sugar.

Stout *(13)* maintained that regardless of whether blueberries were frozen with dry sugar, in sirup, or with no sugar, the net result was a decided toughening of the blueberry skins—a condition that did not disappear after ordinary cooking. Immersing blueberries for 30 to 60 seconds in boiling water, followed by prompt cooling and packing either with or without sugar or sirup eliminated the development of skin toughness in the frozen product.

In a 2-year study of the factors influencing tough skins in cultivated blueberries after freezing and storage, Esselen and Bailey *(2)* found that in the 10 varieties investigated, some would have tough skins one year, but not necessarily the next year. Some berries of each variety were blanched before freezing, but in none of these packs did this treatment prevent the development of tough skins.

From a compilation of procedures for freezing blueberries, the following has been recommended as most applicable for home freezing: (a) preheating the blueberries for one minute in steam and packing without sugar or sirup; or (b) if a sirup pack is desired, covering the berries with 40 percent sugar sirup.

In a study of the effect of various freezing procedures on the palatability of 8 varieties (Atlantic, Cabot, Concord, Jersey, Pemberton, Pioneer, Wareham, and Rubel) of cultivated high bush blueberries, Greenwood, Potgieter, and Bliss *(6)* found no significant change in the relative palatability of the different varieties as fresh blueberries or after freezing. In all tests, berries packed in dry sucrose or sucrose sirup before freezing were preferred to those frozen unsweetened. However, pies made with the frozen unsweetened berries were rated as acceptable as those made with berries sweetened before freezing. During storage periods up to one year, unscalded berries were preferred to the scalded berries; after this time there was little noticeable difference. In none of the berry packs was there any detectable woodiness.

Hayes, Esselen, and Fellers *(7)* recommended the Cabot, Concord, Jersey, Pioneer, Rubel varieties as grown in Massachusetts as well as wild, high-bush blueberries as being suitable for freezing.

EXPERIMENTAL

During the summers of 1951 and 1952, cultivated blueberries grown in the University orchards were obtained for the freezing studies. Inasmuch as Esselen and Bailey *(2)* had reported that a variety after freezing might have tough skins one year, but not necessarily the next, and as the scope of the necessary packs exceeded the berries available from any single variety, it was necessary to combine two or more varieties.

In a study to determine whether or not the earlier maturing berries underwent the same changes in texture as the later maturing varieties, during freezing storage, complete packs of the earliest as well as of the latest maturing blueberries of the 1952 season were prepared.

Greenwood, Potgieter, and Bliss *(6)* observed that although unripe berries change in color from red to blue shortly after picking, the berries maintained their sour flavor. All berries in the present study were sorted as soon as possible after picking to remove underripe and overripe berries. The sorted berries were then washed, drained, and weighed into half-pint or pint home-canning jars fitted with two-piece metal covers. The following packs were prepared: (a) 4:1 dry sugar packs (4 parts of berries to 1 part of sugar); (b) sucrose sirup packs ranging in concentration from 20 to 60°; (c) berries only (no sugar or sirup); and (d) water pack. Inasmuch as interest was evidenced in the acceptability of frozen blueberry packs sweetened with noncaloric sweeteners, additional packs were prepared using sodium Sucaryl and sodium saccharin sirups.

In the preparation of the sirups from the noncaloric sweeteners, sodium Sucaryl was considered to be 30 times sweeter than sucrose *(12)*, and sodium saccharin was considered to be 400 times sweeter than sucrose *(1)*.

In the sirup packs, 170 g. of blueberries and 85 ml. of sirup were used in the half-pint jars, and 300 g. of berries and 140 ml. of sirup in the pint jars. For the dry sugar and all berry packs, 350 g. of the berries with or without sugar were weighed into pint jars.

As soon as possible after packing, the completed packs were placed in a freezing room maintained at —20° F. (—28.9° C.) for 72 hours and then transferred into a 0° F. (—17.8° C.) holding room for storage. At 3-month intervals, samples of each pack were removed and examined for various acceptability factors.

At the scheduled examination dates, the berries were removed from the 0° F. storage and held overnight at room temperature. Drained weight determinations were then made in addition to sirup cut-out values that were measured as percent soluble solids by means of an Abbé refractometer. Table 1 presents the average cut-out values for the various packs.

The texture of the frozen blueberries was measured both subjectively by means of taste panels, and objectively by means

TABLE 1

Cut-out values of sirup, penetrometer measurements and appearance of cultivated blueberries frozen in various packing media

Packing medium	Average of sirup cut-out values	Penetrometer readings		Appearance of thawed berries
		Average	Range	
	(% soluble solids)	*(grams)*	*(grams)*	
Water pack	4.2	144	90-200	
Na Sucaryl ⇔ 30° sucrose	5.4	140	70-170	
Na Sucaryl ⇔ 40° sucrose	5.3	143	100-175	
Na Sucaryl ⇔ 50° sucrose	5.2	141	110-200	Slight shriveling of some berries
Na saccharin ⇔ 30° sucrose	4.8	148	90-180	
Na saccharin ⇔ 40° sucrose	4.6	147	90-190	
Na saccharin ⇔ 50° sucrose	4.5	130	80-160	
20° sucrose sirup	17.8	140	90-175	
Berries only (no sucrose or sirup)	13.9	167	115-190	Slight shriveling of some berries
30° sucrose sirup	25.9	171	105-220	
40° sucrose sirup	33.3	167	95-230	No shriveling—excellent pack
50° sucrose sirup	41.5	192	90-240	No shriveling—excellent pack
4:1 dry sucrose pack	56.6	208	140-300	Noticeable shriveling
60° sucrose sirup	49.1	235	150-300	No shriveling—excellent pack

of a penetrometer-type jelly tester* *(3)*. Inasmuch as the usual head (0.440-inch diameter) for the Chatillon tester exceeded many of the berries in diameter, this attachment was removed, and the shaft of the tester, measuring 0.126 inches in diameter, was substituted. Readings were taken of the number of grams of pressure required for the shaft to penetrate the skin of the blueberry, the blueberries being held on their sides loosely between the thumb and forefinger. From 50 to 100 individual berries of each pack were tested at each examination. The average penetrometer value for each pack is presented in Table 1.

Taste panels comprised of 8 to 10 members of the departmental staff evaluated the texture of the various frozen packs from a subjective viewpoint.

Inasmuch as many frozen blueberries are ultimately used for blueberry pies, it was considered advisable to determine whether noticeable differences in the texture of thawed blueberries would carry through the cooking incidental to the baking of a blueberry pie. Consequently, after 12 months' storage at 0° F. (—17.8° C.), pies were prepared from each of the experimental packs using the following standard recipe recommended by Givens *(5)*: 300 g. of thawed, drained blueberries; 120 g. of sugar; 1 tablespoon of lemon juice, and 2 tablespoons of flour. Using ready-made pie crust mixes, the pies were prepared in 8-inch aluminum pie plates and were baked under uniform conditions of time and temperature.

RESULTS AND DISCUSSION

From the results presented in Table 1, it is obvious that the texture of frozen blueberries is noticeably influenced by the sweetening medium in which they are packed. For all practical purposes, the texture of the berries packed in the 14 different packing media could be divided into three major classes. The blueberries packed in water, sodium Sucaryl, sodium saccharin and the 20° sucrose sirups were quite similar. The thawed berries from these packs were somewhat shriveled and were noted as being "watery" or "chewy."

A second division of the packs on the basis of increased firmness of berries included the all-berry pack and those packs put up with 30 and 40° sucrose sirups. Although a few berries in these packs were shriveled, the berries were noticeably firmer than those of the first group.

The third grouping of packs included the 50° sucrose sirup, the 4:1 dry sucrose, and the 60° sucrose sirup packs, in increasing order of berry firmness. Although there were some shriveled berries in the 4:1 pack, the berries packed in the 50 and 60° sucrose sirups were excellent in appearance with few, if any, shriveled berries. The difference in texture between the berries packed in the 50 and 60° sucrose sirups was quite marked.

One explanation for the increase in berry texture may be gathered from the cut-out values of the sirups which are presented in Table 1. With perhaps the exception of the all-berry pack, the 14 packs could be divided into the same 3 groups on the basis of sirup cut-out values as they were on the basis of penetrometer readings. The fact that the thawed blueberries from the 50 and 60° sugar sirup packs showed little or no shriveling, whereas their sirup concentrations were reduced by 8.5 and 10.9°, respectively, indicates that the transfer of sugar from these sirups into the blueberries was appreciable. This buildup of solids within these berries is in all probability the factor largely responsible for the increased penetrometer readings.

An almost universal observation of the panel members was that in eating the thawed blueberries from those packs included in the first two groups of packs, the individual berries were quite soft and watery. Thus, after chewing a few of these blueberries, the contents of the berries would quickly disappear, but the skins remained in the mouth necessitating considerable additional chewing before swallowing. This brought out the obvious comments that the skins of the blueberries from these packs were "chewy" or tough.

In the third group of packs with noticeably firmer-textured blueberries, the taste panel members did not comment on the presence of tough or "chewy" skins. Apparently the act of chewing these firmer berries, as contrasted to the softer, more watery blueberries in the first 2 groups, subdivided the blueberry skins simultaneously with their contents. In other words, the berry contents and skins were of more nearly similar firmness, and so the skins did not appear to be tough. In fact, the skins gave the appearance of being tender as compared with those of fruit from the first two groups.

An attempted evaluation of berry texture, sweetness, and flavor of the various blueberry pies prepared from the thawed and drained blueberries from the 14 different frozen packs is given in Table 2. As far as texture of the blueberries in the various pies was concerned, there were only 2 pies that were considered somewhat objectionable in this respect. In the first place, the berries in the pie prepared from the 60°

* Manufactured by John Chatillon and Sons, 85 Cliff St., New York, N. Y.

TABLE 2

Acceptability of blueberry pies prepared from frozen blueberries packed in various sweetening media after 12 months' storage at 0° F. (—17.8° C.)

Berries originally frozen in:	Texture of berries in pie	Sweetness of pie	Flavor of pie
Water	good	good	good
Na Sucaryl ⊙ 30° sucrose	good	little too sweet	good
Na Sucaryl ⊙ 40° sucrose	good	little too sweet	good
Na Sucaryl ⊙ 50° sucrose	good	little too sweet	good
Na saccharin ⊙ 30° sucrose	good	little too sweet	good
Na saccharin ⊙ 40° sucrose	good	little too sweet	good
Na saccharin ⊙ 50° sucrose	good	little too sweet	good
20° sucrose sirup	good	good	good
All-berry pack—no sugar or sirup	good	good	good
30° sucrose sirup	good	good	good
40° sucrose sirup	good	good	good
50° sucrose sirup	slight firm berries	good	good
4:1 dry sucrose pack	slight firm berries	little too sweet	good
60° sucrose sirup	noticeably firm berries	too sweet	good
Fresh blueberries (control)	mushy	good	good

sucrose sirup pack were rated as noticeably or unusually firm compared to berry texture normally found in blueberry pies. Secondly, and unexpectedly, the pie prepared from freshly picked cultivated blueberries, originally intended to serve as a positive control, was rated much inferior in berry texture to any of the pies prepared from the frozen blueberries. Although the fresh blueberries may have been of a different variety, the texture of the berries in the pie was unusually mushy.

Although the overall flavor of all blueberry pies prepared from the various packs was rated by the taste panels as being good, the ratings on the basis of level of sweetness was more variable. All the pies prepared from drained blueberries that had originally been packed in the sodium saccharin or sodium Sucaryl sirups as well as the blueberries from the 4:1 dry sucrose pack were rated as being a little too sweet, although not objectionably so.

Obviously, reducing the amount of sugar in the standard pie recipe, reducing the concentrations of sodium Sucaryl or sodium saccharin, or using a 5:1 or 6:1 dry sugar pack in place of the 4:1 pack would lower the sweetness of these packs to a more satisfactory level. Only in the pie prepared with berries from the 60° sucrose sirup pack was the level of sweetness considered excessive. Again in this pack, reducing the amount of sugar in the pie recipe to compensate for the sugar picked up by the berries through osmosis or adhesion would yield a more desirable pie.

It should be observed at this point that the authors were primarily concerned with the effect of various packing media on the texture of frozen blueberries and were only secondarily concerned with the economics of the packs. Thus, the inadvisability of freezing blueberries in sucrose sirups of various concentrations when the consumer intends their end use to be in blueberry pies is realized. The fact that all the pies were prepared from the thawed and drained blueberries meant that, although there was some separation of sirup during drainage of the thawed blueberries in the 4:1 dry sucrose and the all-berry packs, there was considerably more sirup separation from the water, saccharin, Sucaryl, and sucrose sirup packs. Obviously, this sirup could not be used in the ordinary preparation of blueberry pies as such pies are juicy enough (and sometimes exceedingly so) when only berries and sugar are used. Thus, if sirup packed blueberries are employed, the potential use of the separated sirup must be left to the initiative of the individual consumer.

When pies are to be made, the results in Table 2 indicate that the use of (a) an all-berry pack or (b) a 4:1 dry sugar pack with a corresponding reduction of the amount of sugar prescribed in the recipe would give very satisfactory and the most economical blueberry pies.

SUMMARY AND CONCLUSIONS

The results of both subjective and objective evaluations of the texture of commercially cultivated blueberries frozen in 14 different packing media indicated that the thawed blueberries would be classified in the following three groups in order of increasing berry firmness: (a) blueberries frozen in water, sodium saccharin, sodium Sucaryl and 20° sucrose sirups; (b) the all-blueberry pack and those frozen in 30 and 40° sucrose sirups; and (c) blueberries frozen as a 4:1 dry sucrose pack or in 50 or 60° sucrose sirups.

If the thawed blueberries are to be eaten as such, the appearance and texture of the berries packed in the media of group (c) were rated superior, the berries in group (a) and (b) being somewhat more shriveled in appearance and having a more watery texture and seemingly tougher skins.

After 12 months' storage at 0° F. (—17.8° C.) incorporation of thawed, drained blueberries from all experimental packs into blueberry pies minimized the differences in texture between the various packs to the extent that acceptable pies were prepared from all but one of the packs. Only in the pies prepared from berries frozen in 60° sucrose sirup was the berry texture considered somewhat too firm and the sweetness level too high.

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Detection of Washed Eggs by Conductivity Measurements. II. Field Testing

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A reasonably accurate means for distinguishing between washed and unwashed eggs was described in a preceding article. The method employs conductivity as a means of detection. The present article reports results obtained with the conductivity test applied to washed and unwashed samples of eggs from twenty Sonoma County, California, ranches.

Earlier studies were made on laboratory-washed eggs, in which both the washing and drying procedure varied greatly from commercial practice. Accordingly, additional studies have been conducted on ranch-washed eggs. Eggs from a number of ranches using a variety of washing techniques were selected for investigation.

APPARATUS AND PROCEDURE

The conductivity equipment and testing methods were the same as used previously by Hixon, Connolly and Stewart *(1)*. Twenty ranches which consistently washed eggs were selected for study. They were in an area (Sonoma County, Calif.) where washing is prevalent. Samples of approximately 25 washed and 25 unwashed eggs were obtained from each ranch. From two of the ranches, additional samples of presoaked, washed eggs were also obtained. In total, approximately 550 washed and 500 unwashed eggs from 20 ranches were tested.

All eggs were held for approximately 24 hours at ±60° F. and ±80% R. H. before testing. Conductivity measurements were made at these same conditions, using 15 v. The electrodes were placed on the shell and one drop of distilled water (at ±60° F.) was introduced between them; the electrodes were left in the drop for 30 seconds before reading the ammeter. Tests at two different locations on each egg were made.

Table 1 gives pertinent details regarding the various washing procedures encountered.

TABLE 1
Types of egg washing encountered on ranches

Type No.	Description
I	Rubber screw rotates eggs against rubber or plastic covered backboard as egg is carried forward. Wetting is accomplished by screws dipping into tank of static water and by water (from same tank) sprayed upon the eggs. Eggs then conveyed to a towelled-screw which dries them by rubbing action. Heated air used to keep screw dry.
I-a	Ditto except for towel-covered screw on washing section.
I-b	Ditto except for gunny sack-covered screw on washing section.
I-c	Ditto except for rubber screw and backboard on drying sections.
I-d	Ditto except for towel backboard on washing section and use of detergent and water softener; also, no spray used.
I-e	Ditto except no spray used.
I-f	Ditto except fresh water only used and this sprayed on eggs.
I-g	Ditto except that mineral oil (½ lb. to 30 gal. water) added to tank.
II	Rubber rollers turn eggs end-over-end against brush backboards; eggs manually removed when clean. Wetting accomplished by rollers dipping into tank of static water. Drying accomplished by placing washed eggs on Car-Pro lifters in stream of forced, heated air.
II-a	Ditto except for cloth-covered rollers and rubber backboards.
II-b	Ditto except for cloth-covered rollers and Nemite screen backboards.
II-c	Ditto except for cloth-covered rollers and backboards; detergent added to wash water.
II-d	Ditto except for spray on washing section and drying on conveyor belt with heated air stream. Eggs automatically or manually placed on drying belt.
III	Hand-washed, using Na_3PO_4; placed on screen to drain and dry.
III-a	Ditto except hand-washing followed by Type I machine washing.
III-b	Ditto except highly-fluorescent detergent also added.
IV	Presoaked eggs. Heavy dirty eggs allowed to soak in tank of water then washed by Type I machine. Soaking time 5 to 30 minutes.

RESULTS AND DISCUSSION

Table 2 lists the average conductances for washed and unwashed eggs from each ranch. Ranch 10 supplied an additional sample of presoaked eggs along with the regular samples of machine-washed and unwashed eggs; ranch 26 supplied an additional sample of hand-washed eggs along with the usual samples of machine-washed eggs and unwashed eggs.

Student's t test (Table 2) indicates that there were significant differences between average conductivities of washed and unwashed eggs, except for those from ranch 26. The probability (P) was usually less than 0.001; for the entire lot it was much less than 0.001. However, with 2 samples, insignificant differences were obtained.

As indicated above, ranch 26 supplied 2 samples of washed eggs; detergent and water softener were added to the wash water in both cases. The hand-washed eggs (Ranch 26, Type III-b) actually showed a higher mean conductance than the unwashed sample. The concentrations of detergent and water softener were so strong that they could be observed on the shell of the hand-washed eggs as a brilliant blue fluorescence under ultraviolet radiation. The high conductivity values for the washed eggs in these two cases suggest the possibility that the additives from the wash water increased the conductivity of the shell extracts.

There was a total of 5 samples in which additives were used in the wash water. In addition to those used

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TABLE 2

Effect of washing on conductivity of shell eggs

Ranch code	Washed				Unwashed			Diff. ma. mean	t	P
	Type of wash	No. eggs	Ma.[1] mean	Standard error of mean	No. eggs	Ma.[1] mean	Standard error of mean			
10	I	23	.1820	.0095	25	.3252	.0138	.1432	6.13	<.001
10	IV	25	.1648	.0069	...	.....	.....	.1604	7.73	<.001
11	I-c	25	.1856	.0105	24	.2688	.0124	.0833	3.64	<.001
12	II	24	.1746	.0080	23	.3344	.0134	.1598	7.47	<.001
13	II-c	25	.1748	.0078	24	.3177	.0146	.1429	6.36	<.001
14	I-e	24	.1990	.0091	25	.3210	.0137	.1220	5.36	<.001
15	II-b	24	.1871	.0083	22	.2595	.0107	.0724	3.82	<.001
16	III	23	.1672	.0061	26	.3375	.0150	.1703	8.09	<.001
17	I	25	.2132	.0109	25	.3026	.0165	.0894	3.26	<.01
18	I-c	25	.2056	.0109	25	.2932	.0141	.0876	3.50	.001
19	I-b	25	.2010	.0121	25	.2960	0.124	.0950	3.88	<.001
20	II-a	24	.1810	.0087	25	.3044	.0149	.1234	5.24	<.001
21	I-g	25	.1852	.0085	25	.3114	.0132	.1262	5.81	<.001
22	I-a	21	.2100	.0079	24	.2802	.0134	.0702	3.29	<.01
23	I	25	.1646	.0056	26	.2750	.0122	.1104	6.18	<.001
24	III-a	25	.1908	.0088	24	.3410	.0146	.1502	6.43	<.001
25	I-f	25	.2352	.0170	23	.3039	.0151	.0687	2.07	.05
26	I-d	23	.2567	.0112	25	.2598	.0127	.0031	0.13	not sig.
26	III-b	25	.2718	.0232	...	.....	.....	.0120	0.34	not sig.
27	II-a	24	.1812	.0088	25	.3372	.0156	.1550	6.37	<.001
28	II-d	25	.2240	.0085	26	.3423	.0134	.1183	5.39	<.001
29	I	26	.2029	.0130	24	.3398	.0140	.1360	5.08	<.001
Average			.1981	.0060		.3078	.0020	.1097	13.71	<.001

[1] Average of indicated number of eggs in sample. Two tests per egg.

TABLE 3

Relationship of washing method to conductivity

General type wash	No. of samples	No. of eggs	Mean cond. ma.	Standard error of mean	t between I & II	t between II & III	t between I & III	P
I	12	291	.2034	.0071	1.09	.....	.....	None
II	6	145	.1872	.0078	.....	0.58	.....	None
III	3	73	.2099	.0317	.....	.....	0.17	None

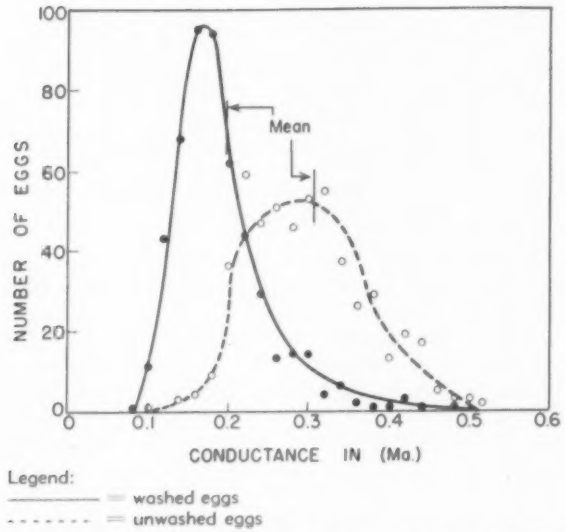

Figure 1. Conductance distribution curves for washed and unwashed eggs from twenty ranches.

on ranch 26, ranch 13 employed an unknown detergent; ranch 16 used trisodium phosphate and ranch 21 added a small amount of light mineral oil to the wash water. These widely different additives did not seem to have any significant effect on conductivity.

It will be recalled that we divided the washing methods encountered into four general types; completely automatic, semi-automatic, hand-washed and presoaked-washed. Tests were made to determine if there was any significance among them. Table 3 shows that there was none. As there was only one sample of presoaked eggs, no comparison with this treatment is included.

In the two instances where a single ranch supplied 2 samples, there was no significant difference between them. (Probability = 0.25).

Figure 1 shows the distributions for the conductances for all of the washed and unwashed eggs. A large portion of the skewness for washed eggs is due to data from ranch 26. However, these 2 samples do not account for all of it; incomplete sampling may account for much of it. The curve for the unwashed eggs is approximately normal.

It will be recalled that there are two types of errors that can be made (when any particular conductance reading is used as a criterion for determining whether an individual egg was washed). They are:

Actual	Found
Washed	Washed
	Unwashed (Type "1" error)
Unwashed	
	Washed (Type "2" error)
	Unwashed

As the overlap of the distributions for the washed and unwashed eggs is quite large, the errors are significant over a wide range of conductances.

TABLE 4

Comparison of Type "1" and Type "2" errors in laboratory and ranch tests

Dividing point ma.	Ranch washed		Lab. washed	
	% Type "1" error	% Type "2" error	% Type "1" error	% Type "2" error
.560	0	100	0	92.40
.480	0.37	98.78	0	83.20
.360	1.68	78.00	0	56.60
.305	5.06	52.14	2.20	39.40
.270	9.36	35.84	4.40	27.00
.240	15.73	20.98	14.80	16.00
.230	18.35	15.48	19.80	13.60
.220	25.47	12.62	25.80	11.40
.200	35.02	5.09	40.80	8.20
.190	42.51	2.04	49.60	5.20
.155	75.09	0.81	81.60	1.40
.110	98.31	0	98.00	0

Table 4 shows the errors at various dividing-point conductances for both ranch and laboratory washed eggs. (Data for the latter are from the earlier report.) The present data on washed and unwashed eggs are quite similar to those obtained on eggs obtained from the University poultry plant and washed under laboratory conditions.

The conductivity test affords a reasonably accurate means for distinguishing between washed and unwashed eggs where excessive use of ionic detergents is not practiced *(1)*.

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Metal Cans of the Future

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As a result of the turn of events in Indochina, the packaging industry is concerned about the supply of tin. The major portion of this paper is therefore devoted to a discussion of the implications of work under way in can manufacturers' laboratories to reduce the industry's dependency on tin. Various sheet metals which have possibilities as alternates for tin plate are discussed, and the broad aspects of techniques by which containers can be manufactured from them are considered. Metal cans for carbonated beverages are discussed briefly.

Concern over the long-term tin situation can be more fully appreciated by examining the sources of the world's tin supply. Figure 1 shows that well over half of the world's production lies in the immediate path of the calculated communist aggression, and that all of this country's tin must be imported over long sea lanes.

Figure 2 shows how the price of tin was affected by another armed conflict in Asia, the Korean hostilities which began in 1950.

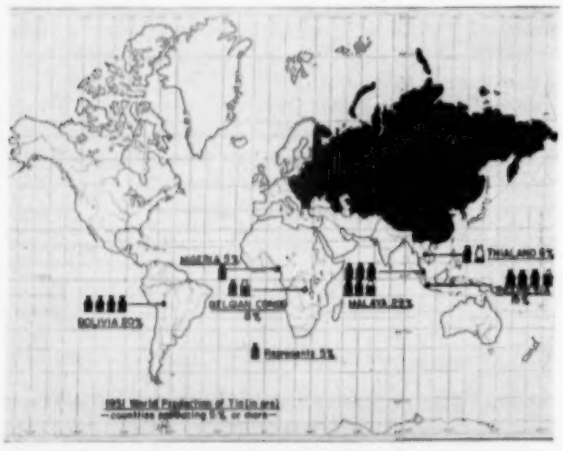

Figure 1. 1951 world production of tin (in ore).

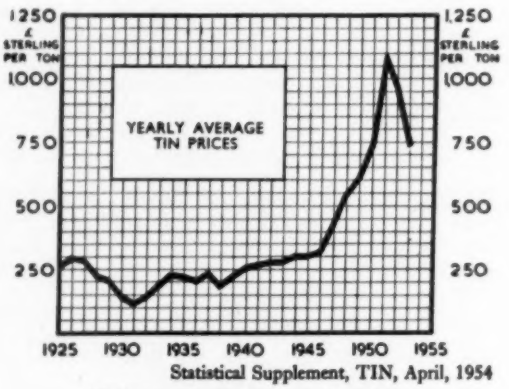

Figure 2. Yearly average tin prices.

Fortunately, the World, and the United States in particular, as shown in Table 1, uses less tin than before World War II.

Most of this reduction in consumption results from tin conservation measures employed in the can manufacturing industry during the war. But as shown in Table 2, the amount of tin employed per base box of plate was further reduced in the post-war years. It was found that in many instances cans with tin coatings as light as 0.25 lbs. per base box would perform satisfactorily under many conditions encountered in domestic distribution. (The base box is the unit of area employed in the tin plate industry, 112 sheets 14 x 20 inches, or an area of 218 square feet.)

In each of the years since 1947 the world has produced more tin than it has consumed. The U. S. Government has stockpiled tin until the strategic reserve is estimated to be large enough to supply the country's needs for several years.

Reducing dependency on tin. Although the stockpiling program provides short term insurance against a

tin shortage, it seemed prudent to initiate a long term program with the goal of developing tin-free cans, first for the non-food household and industrial cans, ultimately reducing, or if possible, eliminating the tin required for food cans. This program permitted an entirely new approach to can making materials and

TABLE 1
Tin consumption *(8)*
Long tons of metallic tin

Year	World (Excluding U.S.S.R.)	U. S. (Excluding tin from detinner)
1937	189,500	72,928
1939	154,500	66,583
1941	173,000	103,086
1943	90,500	46,253
1947	128,000	59,166
1949	117,000	47,163
1951	140,000	56,884
1953	128,000	54,139

techniques. Whereas previous tin conservation procedures had been tied to the use of existing can manufacturing facilities, this program gave the scientists and engineers "carte blanche" to create or search out materials and manufacturing methods by which tin-free cans may be made.

The periodic chart of the elements was the starting point, and each metal produced in significant quantities was studied. After an intensive survey, it now appears that at the present time there is no one metal or metal coating on steel which can serve as a universal alternate for tin plate. One material will be satisfactory for certain specific applications and another for others, but a variety of can making materials will be needed to meet all requirements of all products commonly packaged in tin plate cans today.

TABLE 2
Tin used for tin mill products—U. S. A. *(2)*

Year	Tin mill products	Tin used	Tin coating
	Production in short tons	Long tons	Average per Base box—lbs.
1941	4,100,953	46,900	1.21
1943	2,595,772	22,160	.90
1945	3,581,073	26,821	.79
1947	4,528,983	31,481	.72
1949	4,321,417	30,243	.72
1951	5,573,775	31,289	.59

Most of this paper will be devoted to a discussion of the principal sheet metals which have possibilities as alternates for tin plate and to the broad aspects of techniques by which containers can be manufactured from them.

TIN PLATE

Since tin plate is the material to be replaced, a restatement of the characteristics of this important sheet metal is appropriate. A successful marriage combining the strength of steel and the protective properties of tin, tin plate is so unique that many believe that the canning industry grew as it did around the properties of the steel-tin combination.

In addition to its pleasing appearance, tin plate has other properties which make it attractive to can manufacturers and packagers. Tinned surfaces can be soldered readily and enameled or lithographed, thus making possible high speed manufacture of plain, enameled, or lithographed containers. The thin films of tin, varying with the weight of coating from 15 to 90 millionths of an inch thick, also serve as an excellent lubricant, reducing wear of can making equipment during the fabrication and assembly of container parts.

The tin coating protects the steel from both external and internal corrosion. On the outside of the can, the tin which covers the steel prevents rusting of the tin plate under most of the storage conditions encountered in the domestic distribution of canned foods. Yet if exposed directly to the elements, tin plate disintegrates in a short time, thus effectively disposing of the used can. On the inside of the can, and in the absence of air, tin electrochemically protects the steel from corrosion. It is this unexpected effect, which would not be predicted by reference to chemical textbooks, which really makes practical the canning of many foods.

Tin can be applied to steel by hot dipping or electroplating. The amount of tin on the plate is a factor in the corrosion resistance of tin plate, but also important in food cans is the chemical composition of the base steel. For the most reactive acid products such as cherries, pickles, sauerkraut, etc., type L steel, low in metalloid and residual metal content is specified. Products of intermediate reactivity such as peaches, citrus products, etc., are often packed in cans made of MR plate, which has a higher residual metal content. For the low-acid products such as vegetables and meats, a corrosion resistant base steel is not needed. In fact, the plate used in cans for these products is generally made from steel to which phosphorus has been added to strengthen the plate against buckling and panelling pressures. The chemical specifications for these base steels are shown in Table 3.

TABLE 3
Chemical specifications for base steels

Element	Type L (T-1, 2, 3, 4)	Type MR (T-1, 2, 3, 4)	Type MC (T-5)	Special for beer ends only (T-6)
	Percentage permitted			
Carbon	.05-.12	.05-.12	.05-.12	.05-.15
Manganese	.25-.60	.25-.60	.25-.60	.25-.70
Sulphur	.05 Max.	.05 Max.	.05 Max.	.05 Max.
Phosphorus	.015 Max.	.020 Max.	.07-.11	.10-.15
Silicon	.010 Max.	.010 Max.	.010 Max.	Residual
Copper	.06 Max.	.20 Max.	.20 Max.	Residual
Nickel	.04 Max.	No limitation specified		
Chromium	.06 Max.	No limitation specified		
Molybdenum	.05 Max.	No limitation specified		
Arsenic	.02 Max.	No limitation specified		

The can manufacturer tailors a can for each application, considering the reactivity of the product and the stresses that will be encountered in processing and distribution. As fas as strength is concerned, he can make use of 6 tempers, ranging from T-1, the softest tin plate practical for the mill to produce, to T-6, the stiffest plate practical for the can manufacturer to fabricate. Table 4 gives specifications for the physical properties of the several tempers of tin plate.

Tin plates of T-1 and T-2 characteristics are used in deeply drawn containers such as oval or oblong fish can bodies. Plates of T-3 and T-4 properties are commonly used in the bodies and ends of processed food cans. T-5

TABLE 4

Specifications for physical properties of tin plate

Plate	Temper	Rockwell superficial hardness 30-T		Cup test (.0100" Pl.)	Approximate Schopper value kg./sq. mm.	Anticipated tensile properties in thousands Psi (+)	
		Aim	Permissible deviation			Yield point	Ultimate tensile strength
L or MR	1	49	±3	.320	20-24	39-47	47
L or MR	2	53	±3	.300	23-27	41-50	50
MR	2½	55	±3	.290	24-28	42-52	52
L or MR	3	57	±3	.280	26-30	45-55	55
L or MR	4	61	±3	.260	29-33	49-59	59
MC	5	65	±3	.240	32-36	54-64	64
Beer End	6	70	±3	.200	37-45	....	....

plate is applied where higher panelling resistance is required, such as in the bodies of cans closed under high vacuum. T-6 is employed only in the ends of cans for beer where extreme buckling resistance is required. Figure 3 shows examples of can parts made from plates of the various tempers.

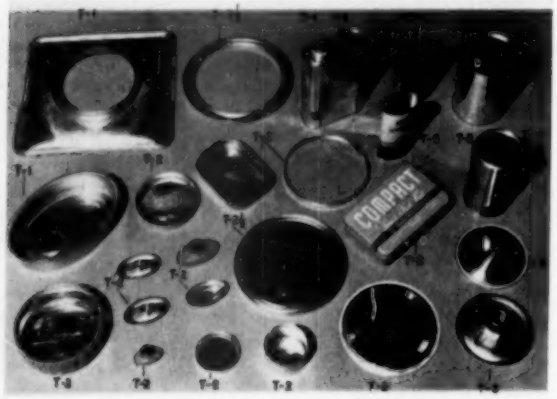

Figure 3. Use of tin plates of various tempers in can parts.

As indicated in Table 5, there has been almost a 50% increase in the country's steel making capacity since 1940. Tin plate production has also increased significantly with electrolytic plate rapidly displacing hot-dipped plate.

The increased employment of electrolytic plate, in large part, represents use of a less expensive container. Prices indicating the current differentials on the various tin mill products are shown in Table 6.

The applications of tin plate, plain and enamelled, in food containers are so widespread that they do not require discussion. Indeed it might be considered unusual to find a product which cannot be packed in some type of tin can. No one alternate material now on the horizon is expected to be applicable for so many items.

TABLE 5

Steel capacities and tin plate productions—U. S. A.

Year	Steel capacity *(6)*	Tin plate and Terne plate production *(11)*	Percentage of tin plate production *(7)*	
	Tons	*Tons*	*Hot dipped*	*Electrolytic*
1940	81,619,000	2,738,000	98*	2*
1945	95,505,280	2,827,483	66.4	33.6
1950	99,392,800	4,640,296	40.6	39.4
1953	117,547,470	....	30*	70*

* Estimates.

TABLE 6

Relative prices of certain tin mill products

Plate	Dollars per base box
Standard Cokes (1.50 lbs. tin/b.b.)	$8.95
Common Cokes (1.25 lbs. tin/b.b.)	8.70
No. 75 Electrolytic	8.05
No. 50 Electrolytic	7.65
No. 25 Electrolytic	7.40
CMQ (Untinned Steel)	6.50

UNTINNED STEEL

In the foreseeable future, most of the tin-free metal cans must be manufactured from steel or steel bearing other metal coatings. There is no other metal produced in sufficient quantity. Table 7 lists production statistics for the principal metals and indicates how they compare with the production of steel and also tin mill products.

TABLE 7

U. S. metals production—1953 *(6)*

Metal	Tons	Steel production	Tin mill products
		Percent	*Percent*
Steel	112,300,000	....	....
Tin Mill Products	5,459,000	....	....
Copper (10 mos.)	2,045,000	1.8 (10 mos.)	37 (10 mos.)
Aluminum	1,253,000	1.1	23
Zinc	977,000	0.87	18
Lead	508,000	0.45	9
Tin (world, long tons)	181,500	0.16	3
Nickel (world)	180,000	0.16	3

Untinned steel has two attributes which make it the leading candidate as an alternate for tin plate. First, it is the least expensive sheet metal. Second, its mechanical properties are essentially the same as those of tin plate. To exploit this material fully, can manufacturers will have to overcome both technical and economic problems. As shown in Table 6, untinned steel (CMQ) costs 90 cents a base box less than No. 25 electrolytic tin plate. Electrolytic plate can be used for many products as received without any organic coating. Untinned steel, however, must be enamelled on both sides to prevent rusting. Assuming the technical problems are overcome, if untinned steel is to replace tin plate to any large extent while tin is still available in quantity, conditions must change so that steel bearing organic coatings on both sides is competitive with plain No. 25 plate.

Fortunately, many non-food cans are lithographed on the outside. In most of these instances steel requires only an inside coating, and the inside-enamelled outside-lithographed steel container can readily compete with

an inside-plain outside-lithographed No. 25 electrolytic plate can.

The technical problems cannot be lightly dismissed, but they are not insoluble. Many years ago hot-rolled sheets were employed for lard pails, tobacco cans, and a few other uses. The plate had a varying amount of black oxide on its surface, and so was called "black plate." Later, pickled and annealed plate was purchased. With the advent of the cold reduction process and the use of deoxidizing annealing gases, plate with a bright steel-gray surface became available. Consumption of this plate increased, and by 1953, 15% of tin mill output was produced as black plate. The industry gradually began to apply the term "can-making quality black plate" for this product, later shortening it to "CMQ plate."

There are several technical reasons why CMQ is not used more generally. The hazard exists of pin point rust occurring during transit from the mill or in storage at the can factory. The exact cause of the rust is not yet known, although many methods of attempting to control it are being employed. The problem is economic as well as technical—not just eliminating the rust, but eliminating it inexpensively.

Figure 4 illustrates the variation in the rust resistance of 2 lots of CMQ plate. The samples were exposed to the same rusting atmosphere for 5 days. The reason for this difference in performance is being investigated. It is hoped that further research will provide a clue as to how the rust resistance of all CMQ plate can be increased.

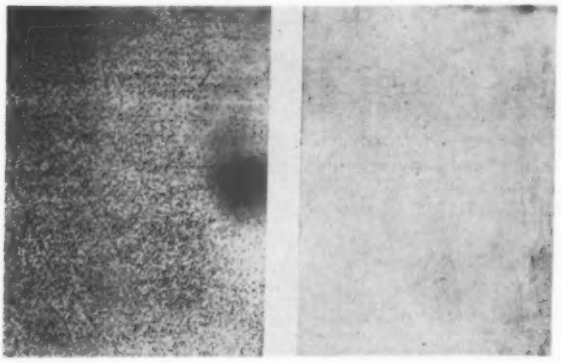

Figure 4. Comparative rust resistance of two CMQ black plates.

Organic coatings for CMQ plate. Many of the organic coatings applied to CMQ plate in the past have been essentially baking varnishes, made by heating together drying oils and fossil resins. CMQ coated with these products was subject to a threadlike corrosion under the coating. Van Loo and associates *(12)* have recently described this filiform phenomenon which occurs rather rapidly under high temperature and high humidity storage conditions. Some of the synthetic resins have been found to reduce the rate at which the corrosion occurs, and recently special coatings have been formulated which should make filiform corrosion considerably less of a problem in the future.

Most organic coatings adhere well enough to CMQ plate to withstand the stresses encountered in can manufacture and distribution. Conventional coatings do not adhere well, however, when CMQ cans are packed with vegetables, meats, and other low-acid foods which require a steam pressure process. To obtain such adhesion, a chemical treatment of the plate was employed during World War II. Now, however, the research trend is toward the introduction into the coatings of ingredients whose specific functions are to enhance the properties of the metal substrate. In fact, organic coatings have been formulated which will adhere satisfactorily to CMQ cans packed with certain pressure processed products.

Development of process resistant inside enamels for CMQ cans and outside coatings which resist both the process and the abrasions encountered in handling should greatly extend the application of the material. Now limited principally to the dry and non-aqueous products, CMQ might well be used for cans for the non-acid food products.

Side seam closure. Difficulty in closing the side seams of CMQ cans has been another important factor limiting the use of the plate up to the present time. Since soldering is the accepted method of closing side seams, and the can manufacturing industry is already equipped to perform that function, the soldering of CMQ plate has received a great deal of investigation. Commercial cans were made from CMQ during and at the end of World War II and again during the Korean hostilities. However, production efficiencies were not high and the strong fluxes required to obtain wetting by the solder caused corrosion of both cans and can-making equipment. Research has now produced less corrosive fluxes and roll salts and even a tin-free alloy which can be used in soldering CMQ plate. However, the soldering operation for CMQ plate still cannot be as readily or conveniently performed as for tin plate.

Welding. Several methods of welding black plate and other sheet metals have been investigated. Since the average plate thickness is less than .01 inch and a high speed can line travels at the rate of over 200 feet a minute, the welding problems are totally unlike any that have been encountered heretofore. Nevertheless, the results obtained with several methods have been sufficiently encouraging to continue the research, and it is quite possible welding will play a more important role in can making in the future than had heretofore been supposed.

Cementing. Cements are the newest can making materials, although cans with bumped side seams have been "doped" with shellac and other substances for many years. The first true thermoplastic cements were introduced into the hooks of CMQ oil cans during World War II—to save both the tin on the plate and the tin in the solder. Until that time tin had been placed on the plate intended for many applications principally to make the plate solderable. With the development of suitable cement and application procedures, it was possible to overcome the necessity of having tin on the plate, and the field for CMQ and other alternate plates was broadened materially.

At the present time most quart motor oil cans are made of CMQ black plate with cemented side seams. The cementing procedure is being rapidly extended into other styles and sizes of cans. It will not only make it possible to produce tin-free containers for many items, but also cans with all-around lithography. Extending the lithography completely around the can makes a much more attractive container. Furthermore, any chance of atmospheric corrosion at the soldered area is eliminated. The cementing procedure, therefore, improves the can from both the technical and esthetic standpoints.

The cementing procedure is expected to be applicable to all of the potential alternates for tin plate. It is, therefore, a technique of major importance to can manufacturers. Recently, research directed toward cements with marked bonding as well as caulking properties has enjoyed success. When cements with the bonding and sealing properties of solder are finally available, they should find rapid application in can making.

CAN MAKING STEEL

In critically examining the attributes and the shortcomings of CMQ plate, it is readily apparent that this product is just untinned steel, designed to tin readily by either the hot dip or electrolytic method. No particular consideration has been given to its end use as steel in containers. It has been proposed, therefore, that a new product be developed with the end use as steel in mind. There are technical reasons for believing that modifications of the processing procedure after cold reduction can result in a product which will be more resistant to rust and underfilm corrosion and to which enamels will better adhere.

From both the mill production facilities and the factory fabrication facilities standpoints, untinned steel has one of the highest potentials as a replacement for tin plate. It may be that the development of a product with improved surface properties is all that is needed to accelerate the transition. As a more appropriate name for such a new product the authors suggest CMS (Can Making Steel).

Chemically treated steel. To obtain the adhesion of enamels, rust resistance, and filiform corrosion resistance which CMQ plate did not provide, large quantities of steel were chemically treated during World War II. Sheets were passed through a proprietary solution which deposited iron and zinc phosphates on the surface of the plate.

Although the use of cut sheets limited production speeds and sludging of the solution reduced operating efficiencies, the plate was employed successfully in ends of cans for a number of vegetable and other non-acid products. However, because the plate was difficult to solder, it was not used extensively in can bodies.

Production of chemically treated plate was discontinued soon after the war ended. The reawakened interest in alternates for tin plate, however, has resulted in reinvestigation of methods for continuously treating coils of steel. The results obtained to date have been encouraging. Attempts are now being made to reduce costs so that the plate may better compete with other sheet metals.

Since enamelled CMQ will probably not be satisfactory for all non-food containers, and process-resistant enamels for the vegetables which will adhere to CMQ are still in the experimental stage, it is likely that chemically treated plate will be one of the first alternates for tin plate. It should be applicable to the ends of cans for the low-acid food products and also for the bodies if ways can be found of soldering it. Extension of cementing techniques for side seam closure should make it possible to employ the plate in cans for a number of hard-to-hold products which do not require processing.

Obviously the quantities of chemically treated plate that will be used will depend upon its price in relationship to other plates and also upon the properties of the can making steel which will undoubtedly be developed in the future.

ALUMINUM

The earth's crust is said to contain about 7% aluminum as compared with 5.06% iron and 0.0001% tin.

As shown in Table 8, aluminum production in the United States has increased greatly since 1940. As far as the metals are concerned, aluminum production is now next after steel and copper. The possibility of aluminum serving as an alternate plate would seem, therefore, to depend upon its physical and chemical properties and upon its price.

TABLE 8
Aluminum production in the U. S. *(10)*
(Tons)

Year	Primary	Secondary
1940	206,280	80,362
1945	495,060	298,387
1950	718,622	243,666
1953	1,253,000	—

Aluminum has physical properties that are both attractive and unattractive to the can maker. The fact that gauge-for-gauge aluminum is only 36% as heavy as tin plate is advantageous. The relative softness of the pure metal is one of its greatest disadvantages.

It was pointed out previously that tin plate is purchased in several tempers whose tensile strengths range from 47,000 to 64,000 pounds p.s.i. Aluminum can also be purchased in various tempers but with considerably lower tensile strength. By the addition of other elements, alloys are formed which are stronger but in general more expensive. In Table 9 are given some of the physical properties of 2S aluminum in five different tempers and also three quarter hard 3S, 4S, and 52S aluminums which have increasing quantities of alloying metals.

The can manufacturer working with aluminum must take into consideration composition and temper, as well as gauge, in tailoring a can to a given requirement.

The price of aluminum ingots over a period of years is compared with the prices of pig iron and tin plate in Table 10. The price of sheet aluminum is not included because there has been no large scale production in the gauges that would be employed for container manufacture.

TABLE 9
Typical physical properties of several wrought aluminum alloys *(4)*

Alloy & temper	Nominal chemical composition	Tensile properties			Hardness Brinnell 10/500
		Ultimate strength P. S. I.	Yield strength P. S. I.	Elongation Percent	
2SO		13,000	5,000	35	23
2S-H12	Al-	16,000	15,000	12	28
2S-H14	99% Min.	18,000	17,000	9	32
2S-H16		21,000	20,000	6	38
2S-H18		23,000	21,000	5	44
3S-H16	1.2% Mn.	26,000	25,000	5	47
4S-H36	1.3% Mn. 1.0% Mg.	37,000	31,000	5	70
52S-H36	2.5% Mg. 0.25% Cr.	39,000	33,000	8	74

TABLE 10
Comparative prices of ingot aluminum, pig iron and tin plate *(1)*

Year	Aluminum (Primary Ingot —cents per pound)	Pig Iron (Composite— dollars/ton)	Tin Plate (Hot dipped— cokes dollars/ base box)
1939	20.0	21.75	5.00
1944	15.0	24.17	5.00
1949	17.0	46.98	7.75
1952	19.4	54.84	8.95

With the price of pig iron more than doubling and the price of tin plate increasing almost 80% in the last 15 years, it is refreshing to note that the price of ingot aluminum is actually less than it was in 1939. By taking into consideration a number of factors, including the lower shipping costs and higher scrap credits with aluminum, it is possible to calculate the price at which aluminum sheet would compete with tin plate gauge for gauge. That price would, however, be considerably lower than the present price.

Actually it is questionable whether the softer aluminum alloys will be satisfactory for a number of applications when employed in the same gauges as tin plate is now used. Packing and distributing are rapid and highly mechanized operations, and cans frequently receive rough treatment. In Europe conditions are quite different and special processing and handling precautions are exercised; apparently cans made from aluminum there are not expected to yield performance equal to that of tin plate cans.

In Europe practically all of the cans made from aluminum are drawn or impact extruded. Ziemba *(13)* reported in 1948 that no high speed methods had been devised for closing the side seams of cylindrical cans. However, the successful manufacture of aluminum cans on conventional can making lines has now been demonstrated.

Aluminum has been soldered on a pilot plant scale, but a number of problems remain. The metal can be welded, but only at speeds lower than manufacturers normally employ. The method of side seam closure which offers greatest promise for aluminum, as for all other alternates for tin plate, is cementing. Aluminum cans with cemented seams are now being evaluated in comparison with similar styles of tin plate cans.

Considerable information is available on the possible applications of aluminum in food containers as a result of commercial experience in Europe and experimental packs in this country. In Norway, where the low cost of electric power makes aluminum relatively cheap and imported tin plate correspondingly expensive, plain aluminum cans have been used for certain marine products where a long shelf life is not required. Anodized cans are used for more food products, and the plate is anodized and then enamelled in order to retain the more reactive products.

In England, and elsewhere on the continent, a variety of types of cans are made from aluminum. The experience of these foreign can makers bears out the results of the domestic experimental packs which indicate that the biggest potential for plain aluminum in containers in the United States lies in the non-aqueous food, household, and industrial products. These applications have been estimated to represent as high as 20% of present can volume. If the price of aluminum can be reduced enough to permit anodizing, the potential volume will increase, and will become even greater if it becomes economically feasible to anodize and then enamel.

Aluminum coatings on steel. The literature contains a number of references to methods of applying aluminum to the surface of steel. Hot dipping, cladding, electroplating, spraying, and vapor deposition are among the techniques discussed *(5)*. The purpose is to effect a marriage similar to that of tin plate in which aluminum will supply the protection and steel the strength.

Although several of the methods are close to the pilot plant stage, it is too soon to discuss the specific properties of the proposed products. The goal is to apply enough of the less expensive aluminum to provide about the same rust resistance as does the more expensive tin when applied at .25 lb. per base box. Under normal domestic canned food distribution conditions, the latter plate performs quite well.

To can makers, a major advantage of the aluminum coatings on steel is that the mechanical properties of such plate will be essentially the same as for tin plate. The cans will be equally strong and much of the equipment employed in the fabrication of tin cans should be usable. Soldering and welding of the new plates will require further exploration. However, cementing will undoubtedly be used for many containers.

The availability of only small quantities of aluminum coatings on steel has not permitted the extensive experimental packs that will be required to define the possibilities of the various plates. At present, it is projected that the applications will be essentially the same as for aluminum itself as far as the non-aqueous products are concerned. There has been considerable speculation as to how aluminum coupled to steel will perform in aqueous systems.

Since the aluminum coatings on steel are currently being produced only on an experimental basis, prices have not been established. To capture a portion of the container market, the prices will have to be competitive with the alternates discussed above.

ZINC PLATED STEEL

Zinc plated steel has been studied as an alternate for tin plate for a number of years. The freshly plated

product lacks the luster desired in a metallic coating and becomes even less attractive upon exposure.

Bonderizing and then enameling the plate stabilizes the surface. However, these additional procedures serve to make the coated plate considerably higher in price than other alternate plates.

The research trend is now toward special chemical treatments which will both brighten and stabilize the surface. Results to date show some promise. If an economical treatment can be perfected which will yield a surface that will retain its metallic luster like tin, zinc plated steel should find application as an alternate for tin plate, principally in cans for non-aqueous non-food products.

NICKEL PLATED STEEL

Nickel plated steel as a can manufacturing material has been considered by the industry since 1930. Over the years a number of experimental packs have been made and the results are of particular interest since they indicate that the plate may be applicable for certain classes of products for which the other alternates are not suitable. Of all the alternate plates thus far tested, nickel plated steel is the one which can be soldered most readily at commercial can making speeds.

The nickel supply situation, however, is not promising. Although, as shown in Table 11, production has increased recently and is being expanded further, nickel is not expected to become plentiful for some years to come *(3)*.

TABLE 11

Nickel production *(10)*
Tons

Year	Canada	World (appr.)
1940	122,779	154,000
1945	121,978	169,000
1950	123,057	160,000
1953	150,000	180,000

To summarize, the sheet metals which at present appear to be potential alternates for tin plate are untinned steel, chemically treated steel, aluminum, aluminum coatings on steel, zinc plate, and later, nickel plate. From them are expected to come the cans of the future.

CARBONATED BEVERAGE CANS

Year after year cans with different closures, pouring devices, and constructions are placed on the market. But this year a container is being re-introduced which is receiving nationwide attention from the general public as well as food technologists.

The carbonated beverage can is a close relative of the beer can but its development required solution of additional technological problems. Experimental work on this container has been under way ever since the first beer cans were introduced by the American Can Company in 1935. However, only with the relatively recent increase in the price of soft drinks have the economics become more favorable to the use of cans.

It is expected that experience gained in the development of the beer can will reduce the time required to establish widespread use of the carbonated beverage can. In 1935 only 160 million beer cans were produced, but by 1953 production had increased to 6,341,730,000 cans. Approximately 29% of packaged beer and 21% of all beer was placed in cans. The 6.3 billion cans represented about 18% of the 35.6 billion can total output of the can manufacturing industry.

The carbonated beverage industry last year packaged approximately 28 billion units. Thus the potential increased market for cans is tremendous. In fact, if the same pattern is followed as with the beer can, can manufacturing facilities will have to be expanded by one-third.

Because of this tremendous potential market, can makers are keenly aware of their responsibility in making every effort to insure that their products retain the quality of the beverages. The most corrosion resistant base steel must be employed and special protective coatings applied to the tin plate. High strength side seam and end constructions must also be used. In fact, much of the considerable fund of information that has been accumulated over the last 19 years while improving the quality and reducing the cost of the beer can must be applied in manufacturing the carbonated beverage can.

As was true with the early beer cans, both flat top and cone top carbonated beverage cans are being placed on the market. In the instance of the beer can, production of the cone top gradually diminished in favor of the less expensive flat top can. Since the flat top carbonated beverage can is also less expensive than the cone top, the same trend may prevail. Regardless of which style ultimately receives greater consumer acceptance, the carbonated beverage can is expected to be another example of the new containers which have played such as important role in the continuous growth of the can manufacturing industry.

Acknowledgment

The authors wish to acknowledge the contributions of their associates whose work is described in general terms in this paper; also to Harriet Bible for library assistance.

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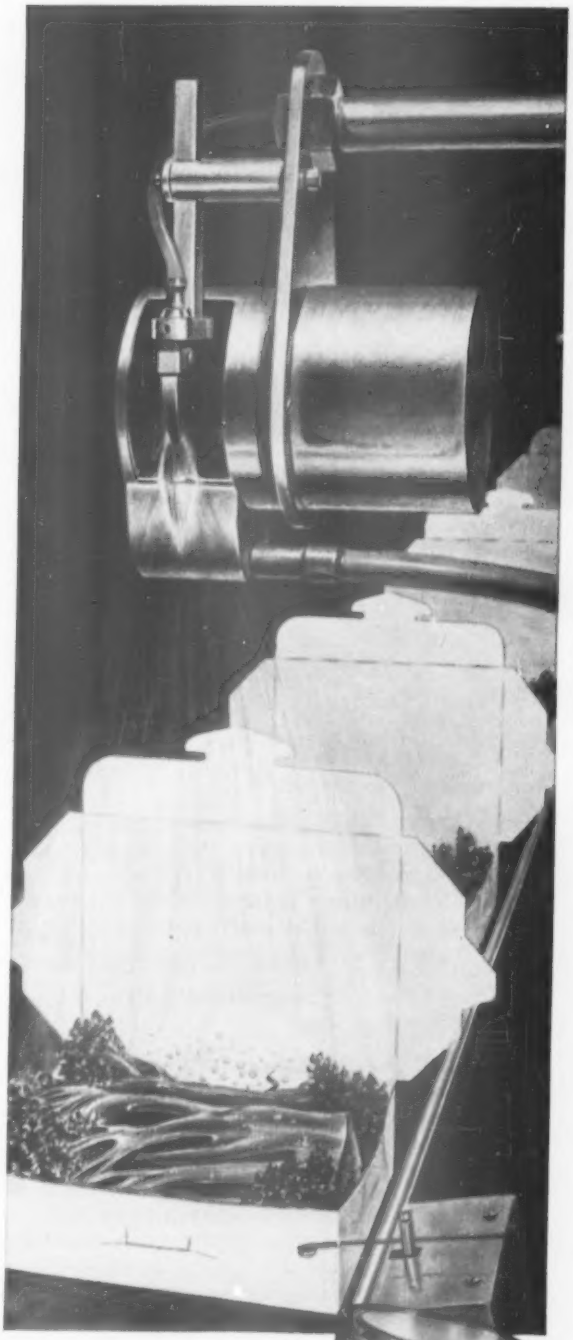

New Ac'cent Machine gives flavor-edge to frozen foods

Now, after three years in the development stage, a new Ac'cent dispenser makes it possible for frozen vegetable processors to enjoy the flavor enhancement advantages of Ac'cent!

Accurate measurements of monosodium glutamate in a liquid solution are applied by the new machine to vegetables before freezing. It is an automatic, high-speed operation—efficient and economical.

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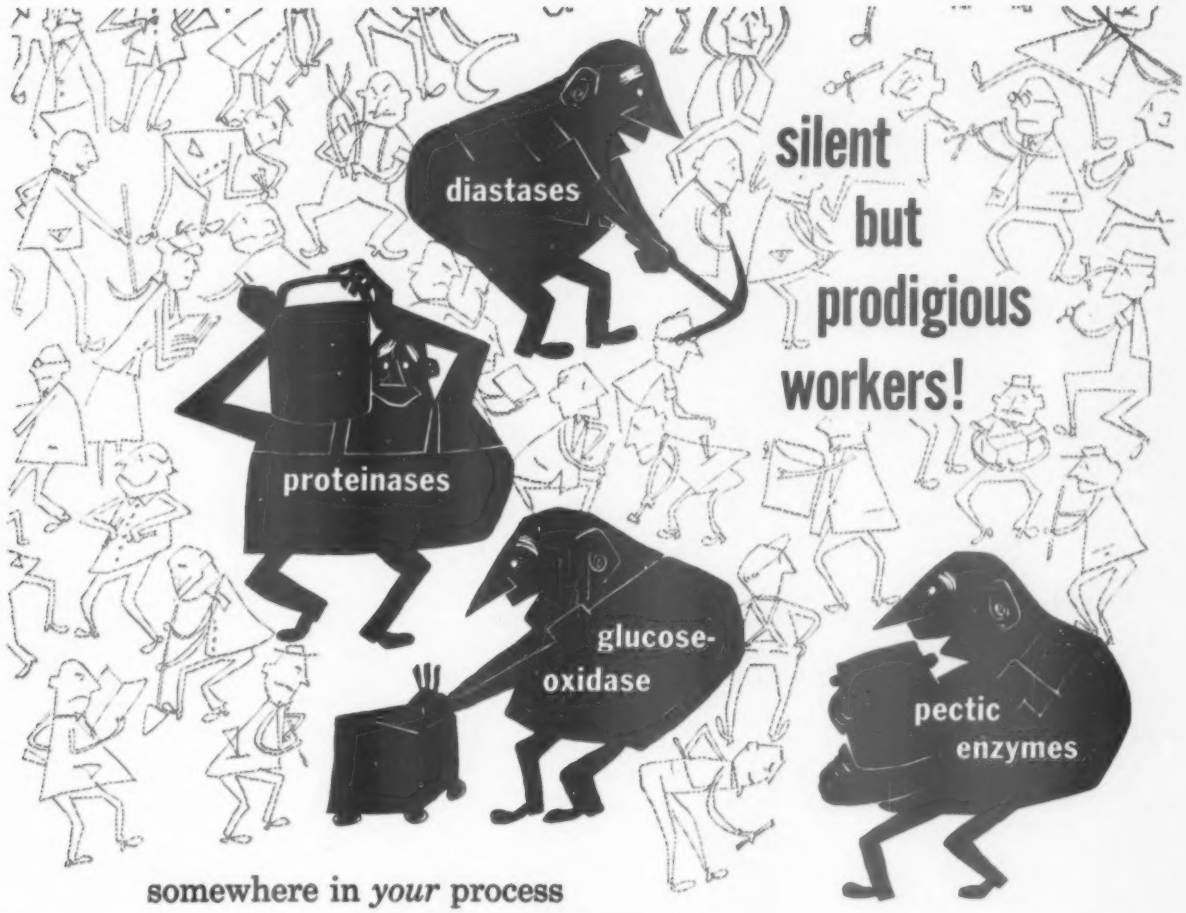

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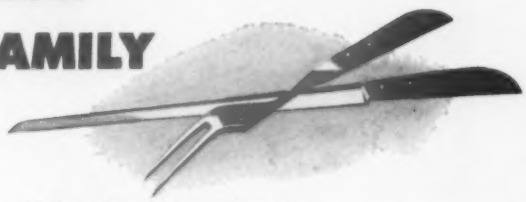

A canned whole ham is just the ticket for a large family or a gala dinner. However, there are a tremendous number of smaller families who want just enough to serve them for a meal or two.

So today packers tailor ham in many sizes. And Continental provides convenient pear-shaped cans to fit. Our largest ham can holds up to fourteen pounds of solid meat—an entire ham, which has been boned, skinned and pre-cooked. The smallest holds just a pound and a half.

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These include not only ham and luncheon meat, but stew, sausage, chili, tamales, hamburgers, tongue, and meat spreads. All are pure, nourishing and economical. All can be made ready for the table in minutes. Many also make quick sandwiches.

Continental research people are constantly working to improve both meat processing and packing methods. We welcome the problems that new meat products often bring. In fact, from our abundance of packaging materials, there are few products for which we cannot tailor a package that exactly fits the needs of the product, the packer, and the consumer.

(This advertisement originally appeared in full-color in TIME, BUSINESS WEEK and FORTUNE.)

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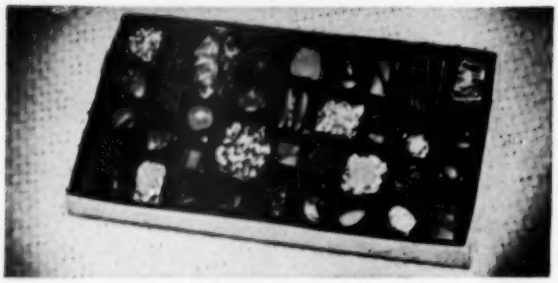

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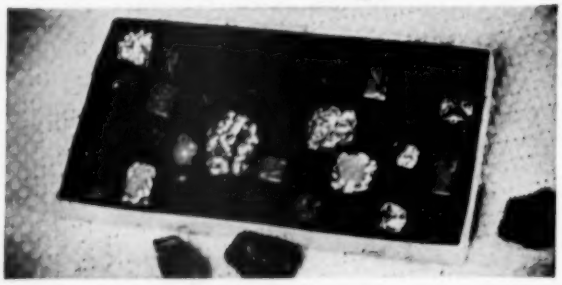

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Books

PRINCIPLES OF SUGAR TECHNOLOGY. Ed., P. Honig. Elsevier Publishing Company, New York, 1953.

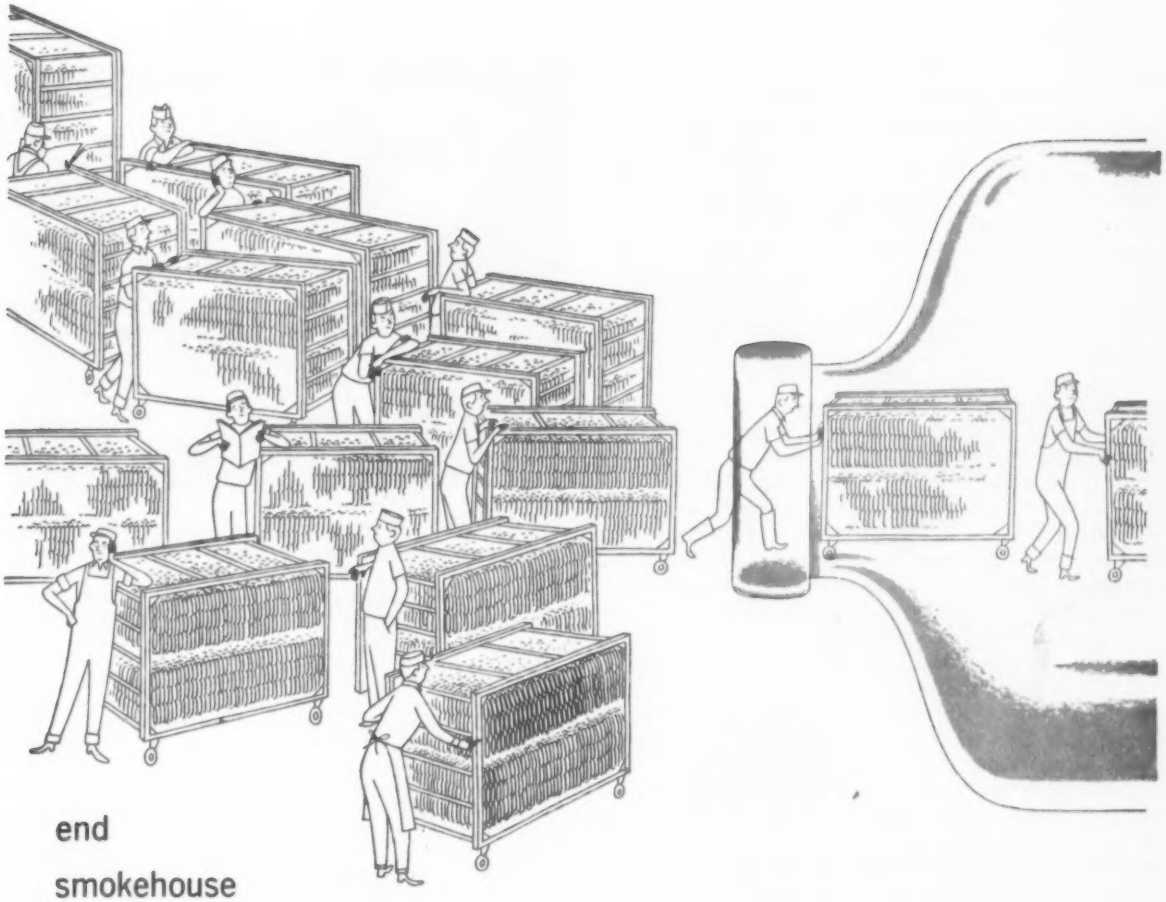
The preface to this book states in effect that the major reason for its preparation is the substantial disagreement between modern physical and chemical knowledge and " . . . the common theories and way of thinking existing among sugar technologists." For the purpose of clarifying a situation in which " . . . a . . . number of vague statements . . . are accepted by many practical sugar technologists as if they were laws of nature. . . . " Dr. Honig has assembled contributions from an international group of industrial and government sugar experts.

The chapters are arranged in two broad sections; one entitled "Physical and Chemical Properties of Sugars and Nonsugars" and the other "Purification of Technical Sugar Solutions." In both sections the attempt has been made, subject by subject, to survey the literature critically and as well as assembling it, in some cases at least, to point up those areas in which fundamental data essential to technological progress in the industry are lacking. It is regrettable that even more attention was not paid to this latter objective since in this field, as in so many other areas of research, the main problems have been obscured by vast collections of uncontrolled experimental observations.

The editor of this handbook (and contributor of three important chapters) has been emphasizing the viewpoint he expresses in the preface for many years. There is no doubt in this reviewer's mind that Dr. Honig is quite correct in his assertions. To a reasonable extent he has succeeded in this book in illustrating the deficiencies in present day sugar technology. The volume succeeds better, however, with respect to assembling several well conceived and well written reviews, particularly in the critical areas of clarification (P. Honig, J. G. Davies) and process control (G. W. Payne). Furthermore, there have been collected in the first part of the book, for the first time in recent years and therefore more completely than heretofore, the nature and composition of the nonsugar constituents, both organic and inorganic, of cane juice and raw sugar. Frequent references to the beet sugar industry are also valuable.

Unfortunately, a high level is not maintained throughout the book. The first chapter particularly, on chemical properties of sucrose, suffers from both a somewhat static idea of sugar chemistry and poor translation. A reader stopping at this point in his investigation of the handbook might be disinclined to proceed further. This would be a mistake, however, since most of the succeeding chapters are competently prepared. Chapter 3 by Emma J. McDonald entitled "Physical and Chemical Properties of Dextrose and Levulose" is excellent and Miss McDonald should have been asked to expand her coverage. Excellent also are the chapters by L. F. Martin, particularly that entitled "The Non-Nitrogenous Organic Acids of Sugarcane." The chapter by L. F. Wiggins on amino acids and proteins and that by R. T. Balch on "The Lipids of Sugarcane" are noteworthy. In many ways a good share of the first section of the book is a monument testitfying to the important role the various techniques of chromatography have played

(Continued on page 36)



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smokehouse
bottlenecks with

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● When you add Pfizer Ascorbic Acid or Sodium Ascorbate to cooked, cured, comminuted meats you reduce considerably the time required in the smokehouse. That means an end to bottlenecks and results in increased production. Some packers have stepped up smokehouse capacity by ⅓ or more.

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BOOKS

(Continued from page 34)

in our better understanding of the complexities of natural products.

The chemical section of the chapter by T. R. Gillett entitled "Color and Colored Nonsugars" is perhaps lacking in criticalness. The author has apparently attempted to cover too much ground and in addition, too much emphasis has been placed on older ideas of color formation. On the other hand, the review of color measurement which this chapter also contains is excellent.

Those chapters which deal more with the technology of purification in part two of the book are generally of high quality and it is difficult to single out any one for particular comment. The two chapters by J. H. Payne entitled respectively "Fundamental Reactions of the Clarification Process" and "Ion Exchange" are very well prepared and will be welcomed for the many illustrations which they contain. Part two also contains noteworthy evaluations of the carbonation process (P. Honig) and sulfitation process (J. Marchés).

In general it might be said that the volume suffers somewhat from lack of editorial attention, and we hope that this may be corrected in future editions. Nonetheless, it is an important addition to the library of sugar technologists as well as to those who would understand the problems facing sugar technologists today.

With respect to the latter point, if those in the sugar industry responsible for approving research budgets do no more than read the preface of this book and the conclusions of some of the chapters, notably chapters 11, 12, 13 and 18, perhaps the poor situation with respect to availability of fundamental information, which Dr. Honig so rightly decries, can begin to be corrected.

SIDNEY M. CANTOR
Philadelphia

FUTURE MEETINGS FOR FOOD TECHNOLOGISTS

1954	
September 1	American Soybean Association, Memphis, Tennessee
September 6-8	American Institute of Biological Science and the American Society for Horticultural Science, Annual Conference, University of Florida, Gainesville
September 12-17	National Meeting of the American Chemical Society, New York, N. Y.
September 13-15	American Fisheries Society, Seattle, Washington
September 16-18	National Poultry, Butter and Egg Association, Hotel Sherman, Chicago, Illinois
September 26-29	Mayonnaise and Salad Dressing Manufacturers Association, Hershey Hotel, Hershey, Pennsylvania
October 1-6	American Bakers' Association, Chicago, Illinois
October 8-12	American Meat Institute, Annual Meeting and Exposition, Palmer House, Chicago, Illinois
October 12-15	National Chemical Exposition, Coliseum, Chicago, Illinois
October 11-16	Dairy Industries Supply Association, Atlantic City, New Jersey
November 15-18	International Soft Drink Industry Exposition, Convention Hall, Philadelphia, Pennsylvania
June 12-16, 1955	**Institute of Food Technologists, Hotel Deshler, Columbus, Ohio**

(Information concerning future dates of national and international meetings, conventions and exhibits of interest to food technologists should be sent to the editorial office.)

. . . *in the public interest*

From a man who should know, Dr. B. E. Proctor, professor of Food Technology, Massachusetts Institute of Technology, came the following remarks on a popular subject, in the course of a paper presented at the 63rd annual meeting of the National Association of Refrigerated Warehouses, Inc. "Perhaps the day is not far away when atomic energy may have great significance in times of peace as well as of war. One might predict that an important peacetime use of atomic energy might sometime be to extend the storage life of perishable foods by the combined use of gamma radiation from radioactive wastes and subsequent storage at refrigeration temperatures. If this prediction proves to be accurate, such use of atomic energy would augment the already strategic services that your great industry has for over a century provided for the food industries and the general population of this wonderful country in which we are fortunate to live."

◆ ◆ ◆

Research in science and its close relation to the science teaching program of Tuskegee Institute is the theme of the 1952-53 Annual Report of The George Washington Carver Foundation. Since 1945, the Carver Foundation has awarded $63,570.00 to a total of 47 graduate students, thirty of whom have achieved the M.S. degree.

◆ ◆ ◆

To provide standardization in the vitamin assay of foods in various countries, and thus to facilitate international trade, a Vitamin Commission has been organized under the auspices of the Food Division of the International Union of Pure and Applied Chemistry, with Prof. E. Brunius of the National Public Health Institute, Stockholm, Sweden, as chairman. The additional members are: Dr. W. F. G. Cuthbertson, Glaxo Laboratories, Ltd., England); Dr. Max Kofler (F. Hoffmann-La Roche and Co., Ltd., Switzerland); Dr. Bernard L. Oser (Food Research Laboratories, Inc., United States); Dr. Henri Simonnet (National Veterinary School and National Agronomic Institute, France). The Commission will explore vitamin procedures specifically adapted to food products entering into international commerce. It will attempt to utilize the standardized methods of the numerous organizations within the several countries that have engaged in standardization work, and to integrate and adapt these methods for use at the international level.

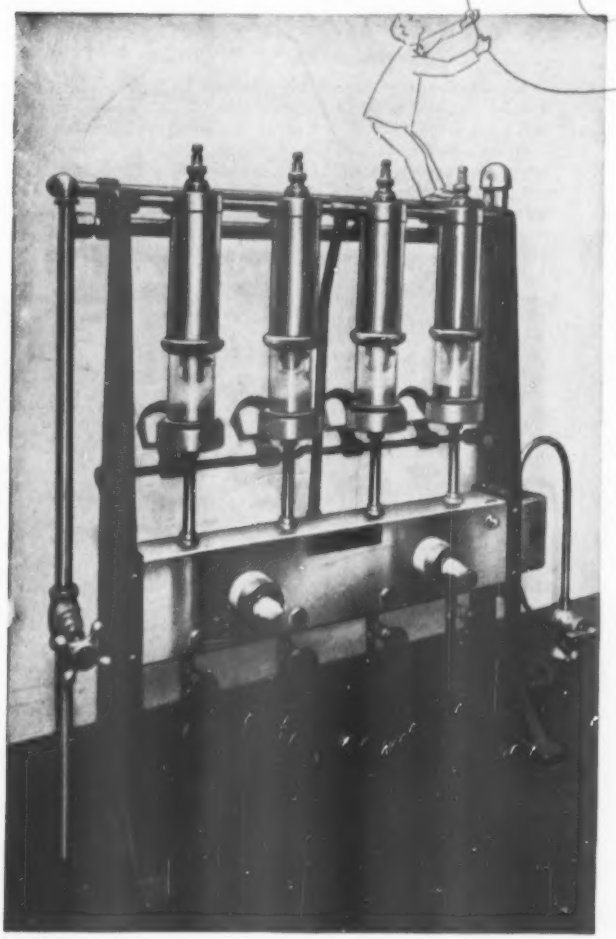
◆ ◆ ◆

Vitamin deficiency is now known to be among the causes of at least 11 nervous or mental disorders, according to a report in a recent issue of *The Journal of Clinical Nutrition*. Disorders listed involve such symptoms as mental deterioration or depression, hysteria, defective memory, loss of sense of location, loss of sense of truth, hallucinations, ideas of persecution, anxiety, irritability, etc. Authors of the paper, which is a

(Continued on page 38)

How Griffith's Extraction Process Assures Better-Flavored Products

PEPPEROYAL AND SOLUBLIZED SEASONINGS



True Flavors in Smooth, Mellow Blend —The Taste of Sunshine All the Time

In this age of scientific miracles, Griffith's staff of chemists enables you to change a good product into a delicacy—simply by changing to PEPPEROYAL or SOLUBLIZED SEASONINGS.

Griffith's Solublized Seasoning Formulas set a new high standard of flavor potency, purity and uniformity. By a special extraction process,* Griffith controls flavor quality. Blends spice extractives scientifically — with predictable, dependable results for spice users!

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Write us for details.

* Patent Applied For.

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FOOD INDUSTRY TOPICS

(Continued from page 36)

summary of research in the role of vitamins in nervous and mental disease, are Dr. Robert A. Peterman, medical director of J. B. Roerig and Co., Chicago, and Dr. Robert S. Goodhart, scientific director of the National Vitamin Foundation, New York City. Their report summarizes 74 studies, of which 60 have been published since January, 1950.

◆ ◆ ◆

Culminating several years of research, the American Meat Institute Foundation shortly will issue an official Foundation Bulletin which will provide detailed information regarding the antioxidant value of Butylated Hydroxytoluene (BHT) when used in lard and other animal fats and regarding the carry-through protection afforded to foods and feeds in which BHT-treated fats have been used. Development of Butylated Hydroxyanisole (BHA), now used in some 50% of all lard produced commercially and in feed grade tallows and greases, was announced by the Foundation in 1948.

◆ ◆ ◆

"Cutting down in the total amount of food eaten is the primary problem in reducing" states a pamphlet, "What Makes People Fat?" issued by Sugar Information, Inc., 52 Wall St., New York 5, N. Y. Citing facts documented by the Department of Nutrition of Harvard University's School of Public Health, the pamphlet reports that healthy people get hungry when their blood sugar level is low. Since sugar raises the blood sugar level faster than any other common food, states the pamphlet, its use before and during meals makes it easier to eat less of everything. Copies may be obtained free of charge.

◆ ◆ ◆

Major research into the use of canned foods in restaurants and other away-from-home eating places is being undertaken by the Can Manufacturers Institute, New York City. The CMI study is designed to provide basic information on institutional food practices, including attitudes toward canned foods as well as usage, according to Mr. Harold H. Jaeger, director of the Institute's Marketing Bureau. More than 200 eating places will be studied intensively, and results will be available in the early Fall.

◆ ◆ ◆

Color is one of nature's air-conditioning gifts, according to findings of the Color Research Laboratories of Sun Chemical Corp., 10th St. and 44th Ave., Long Island City 1, N. Y. Recent tests show that color staves off the discomforts of heat and can actually be used to control temperature in storage areas and packaging. In one of their specialties—printing inks—Color Research reports findings of particular interest to warehousemen. Food packages in light tints—especially orange and green—reduce spoilage by absorbing ultraviolet rays which, studies show, cause the worst damage. Similarly, light-colored packages remain cooler to the touch than dark colored packages, and, consequently, their contents are less apt to melt.

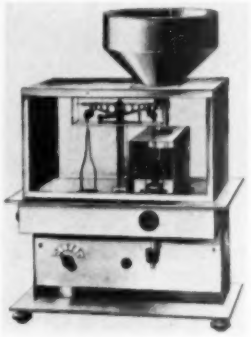
. . . *things new under the sun*

Continental Can Company's Research Division, 4645 W. Grand Ave., Chicago, Ill., has developed a simple bacteriological medium which has been found useful for the **growth and isolation of spoilage organisms from canned foods.** The new medium, developed by Dr. Clarence F. Schmidt in 1950, has been designated as PE-2. Data obtained from experiments conducted to evaluate the medium have been published by J. F. Folinazzo, research chemist, and V. S. Troy, section chief. Reprints of the published report are available from the company's Research Division.

◆ ◆ ◆

An electronic clinical thermometer, Swiftem, manufactured by the Burlington Instrument Co., Burlington, Iowa, may eventually replace the familiar glass stem mercury filled thermometer in use for the last 86 years. The remarkable speed of 3 to 5 seconds to obtain a reading with the Swiftem, coupled with high accuracy, saves many minutes for the physician daily. In addition, clinical thermometry horizons are widened by the prospect of wired beds so a patient's temperature may be recorded continuously in a distant control room under the watchful eyes of the hospital staff. The firm states that commercial availability of the instrument within the next few months is planned. Other models for home and industrial use will be developed.

◆ ◆ ◆



A machine that automatically net-weighs and dispenses into containers any non-liquid product that will pass through a hopper is announced by National Instrument Co., 5005 Queensbury Ave., Baltimore 15, Md. The Filamatic Universal Weighing and Filling Machine handles materials as divergent as powders, tea, tacks, tablets, seeds, and candies. There are no stirrers or agitators of any kind and no mechanical cut-off. A vibrating type feeder insures accurate dispensing, even with hygroscopic and fatty, non-free flowing powders. Filling speed is variable from 600 to 2000 fills per hour, depending on the type of material and weight of fill.

◆ ◆ ◆

Ice cream pies that can be produced by four people at the rate of 600 per hour are offered in a unique package deal by McCarthy Fruit Products Co., 1715 Church St., Evanston, Ill. Introduced with success to the trade in 1953, the McCarthy Luscious Ice Cream Pie Plan includes 1000 pies, 1000 four-color display cartons, six five-gallon pails of pie filling, a hand stamp for each flavor, and full technical service to set up the line. Window streamers, ad mats, and spot announcements are also included.

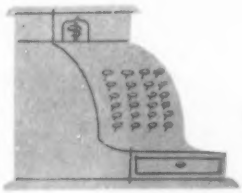
◆ ◆ ◆

American Can Company is currently researching the possibilities of **preserving canned food by means of ionizing radiation** instead of by conventional heat sterilization. Here a panel of expert food tasters at American Can Company's Maywood, Ill., research laboratories is sampling canned meat preserved by gamma radiation from radioactive material. The meat had been in cans, samples of which are seen in the foreground, for about five months and the tasters declared it to be in good condition except for a "slight off taste." It had the natural texture and appearance of cooked fresh meat. The company reported, however, that even if canning by radiation does prove feasible in the long run, many problems including cost and various public health considerations will have to be solved before the new process becomes a commercial reality.

. . . *the literary corner*

"There is something similar to the inventor's pride of creation in every flavor chemist. When one of our modern flavorists finds a new and novel use for an old aromatic chemical or essential oil, there is a justified satisfaction with the results. Should the idea, for example, that the use of allyl caproate in

(Continued on page 40)



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can ring up more sales for you

Sheffield milk proteins are today helping to bring increased sales and profits to many enterprising food processors. These milk proteins serve as excellent dispersing, stabilizing and water binding agents in many foods—ice cream mixes, bread, doughnuts, processed meats, infant food and others.

By supplementing your food products with high quality milk proteins, you get these important, profitable benefits:

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- *Improved texture*
- *Increased shelf-life*

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Milk proteins are only one of many products of Sheffield research, all directed toward supplying food processors with superior ingredients. Our research department will gladly work with your laboratories to develop new products or improve old ones. For detailed information, write: *Sheffield Chemical Company, Food Division, Norwich, N. Y. — or to our branch office at 1267 Sixth Avenue, New York 19, N. Y.*

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MILK PROTEIN EDIBLE POWDER
HIGH NITROGEN CASEIN
SODIUM CASEINATE POWDER
CALCIUM CASEINATE POWDER

LEADS THE FIELD IN MILK PROTEINS

A DIVISION OF NATIONAL DAIRY PRODUCTS CORPORATION

FOOD INDUSTRY TOPICS

(Continued from page 38)

an orange flavor inflate his artistic soul to unrealistic proportions, he has his untutored predecessor's accomplishment, in antiquity, to give him the proper sense of humility. We are speaking, of course, of the vassal of Montezuma who first used the cured vanilla pod to combine with the fermented roasted seed of the cocoa tree to form 'chocolatl'." The above is the first in a series of delightful paragraphs comprising the feature article in the No. 3, 1954 issue of *The Givaudan Flavorist*, entitled "The Perfect Marriage—Vanilla and Cocoa." *The Flavorist* is published by Givaudan Flavors, Inc., 330 W. 42nd St., New York 36, N. Y.

◆ ◆ ◆

The Seaplant Chemical Corp., New Bedford, Mass., has recently undertaken the publication of a house organ entitled "SeaKem EXTRACTS." Vol. 1, No. 1 features stories on various uses of SeaKem Irish Moss extractives in food, drug, cosmetic, and industrial stabilizing problems. To be put on the mailing list, write Mr. Byron Spence, General Sales Mgr., Seaplant Chemical Corp., 63 David St., New Bedford, Mass.

◆ ◆ ◆

Environmental test cabinets for JAN and MIL tests, product evaluation, and research activities are shown in new Instrumentation Data Sheet 11.0-8, published by Minneapolis-Honeywell Regulator Co., Industrial Division, Wayne and Windrim Aves., Philadelphia 44, Penna. The firm also announces addition of three types of extension wire to the product line—a 14-gauge extension wire with asbestos or waterproof insulation, a 14-gauge Chromel-Alumel wire also with asbestos or waterproof insulation, and a 20-gauge Chromel-Alumel extension wire with waterproof insulation.

The "Coronary Club Code," or ten rules to be followed by any executive seeking brief membership in the Coronary Club with its bonus of a shortened life, is quoted in the Summer 1954 issue of The Chemical Digest, publication of Foster D. Snell, Inc., 29 W. 15th St., New York 11, N. Y. Rule number one of the Code—"Your job comes first; personal considerations are secondary."

◆ ◆ ◆

Just issued—the latest Fritzsche wholesale price list on absolutes, fixatives, aromatic chemicals, colors, citrus concentrates, essential oils, etc. Copies are available to those buying in wholesale quantities. Write Fritzsche Brothers, Inc., Port Authority Bldg., 76 Ninth Ave., New York 11, N. Y.

◆ ◆ ◆

For the man with the problem of specifying refrigeration and air conditioning equipment in the range of capacities from 15 through 220 tons, Acme Industries, Inc., Jackson, Mich., recommends its new catalog on Acme Flow-Therm packaged Liquid Chillers. Sales engineers at Acme have reportedly developed a new idea in selection procedures that enables the user to obtain a unit tailored to his exact requirements, yet embodying all of the advantages of a factory-assembled and tested "package." Write Dept. 200 for the catalog.

◆ ◆ ◆

Written as a text and reference manual, the new filter press catalog and specification book published by D. R. Sperry Co., Batavia, Ill., contains classified sections devoted to full discussions on the nomenclature and advantages of the plate filter type press as well as the terminology and step-by-step digest of the entire filtration operation. For free copies write Dept. FTE.

(Continued on page 42)

Is a link missing in your Quality Control Chain?

But he can *be prepared* in advance to spot the trouble *the moment it occurs* by using

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No Food Technologist can tell *in advance* when a batch is going to "go bad."

...TIME-TEMPERATURE SPECIFICATIONS FOR FREE COOK-...ATORS CUSTOM-MADE TO FIT YOUR REQUIREMENTS

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With Zest,® 99+% Pure Monosodium Glutamate, Food Processors Make Foods More Flavorful Than Ever!

AMERICA'S LEADING FOOD PROCESSORS USE THESE STALEY PRODUCTS

Staley's 99+% Pure Monosodium Glutamate—pure, free-flowing crystals that intensify natural food flavors.

Corn Syrup—Sweetose Brand-high conversion sweetener for firmer texture, better flavor.

Corn Oil—A vegetable oil of highest quality for cooking and food processing.

Lecithin—An established emulsifier and antioxidant for the Food Industry.

No need to let heat, pressure and other processing conditions rob food of taste appeal. Zest magnifies the natural flavors without adding any flavor, color or aroma of its own. Whether your products are frozen, dehydrated or canned, Zest brings out all their natural goodness—puts them first on the consumer's shopping list.

A. E. STALEY MFG. CO., ***Decatur, Ill.***

Zest — Staley's

Industries Served by Staley Products

BAKING • CONFECTIONERY • ICE CREAM • FOOD PROCESSING

FOOD INDUSTRY TOPICS

(Continued from page 40)

Indicating and recording systems for use with standard Richardson scales are described and illustrated in a new technical reference offered by Richardson Scale Co., Van Houten Ave., Clifton, N. J. Briefly described is the sequence of operations involved in the weighing, indicating, and recording processes. One section discusses such features as time delay before full-balance printing, partial draft printing, and provisions for recording time and date. Write Mr. Richard Steensma for Technical Reference 53J at the above address.

◆ ◆ ◆

The Nitroparaffins are the subject of Technical Data Sheet No. 23 recently published by Commercial Solvents Corp., 260 Madison Ave., New York 16, N. Y. Included are tentative CSC specifications, physical properties, chemical reactions, toxicity, and shipping, handling, and storage data on Nitromethane CH_3NO_2, Nitroethane $CH_3CH_2NO_2$, 1-Nitropropane $CH_3CH_2CH_2NO_2$, and 2-Nitropropane $CH_3CHNO_2CH_3$.

. . . *building up and branching out*

As another step in Huron Milling Company's recently inaugurated program for strengthening distribution channels for Huron MSG (monosodium glutamate) and Huron HVP (hydrolyzed vegetable protein), the firm has named Koehler Brokerage Co., 920 W. Broadway, Louisville 3, Ky., as the Huron representative in certain areas of Indiana and Kentucky. Specifically, Koehler will service firms in the food specialty business, canning industry, and meat packing trade, whose need for Huron MSG and HVP has grown considerably in the past few years under the impact of consumer demand for better-tasting food products.

Frutaste flavors!
The Economy Line
HIGH CONCENTRATION
•••LOW COST PER BATCH
NEUMANN, BUSLEE & WOLFE, INC.
5800 NORTHWEST HIGHWAY CHICAGO 31, ILL.

. . . *the human element*

A group of three scientists at the USDA's Eastern Utilization Research Branch, Philadelphia, recently received the Department's second highest award—its Superior Service Award—for developing a process for intensifying the flavor of maple sirup. Recipients of the Award were **Dr. Charles O. Willits, Dr. William L. Porter,** and **Miss Margaret L. Buch.** The process is expected to lead to development of new and improved maple products and superior maple blends.

◆ ◆ ◆

Caught in an informal pose on a cruise to Catalina Island during the recent Los Angeles annual meeting of the Research and Development Associates, Food and Container Institute, Inc., were, left to right: **Col. Rohland A. Isker** (ret'd), Associates secretary; **Mr. John Beckett,** technical director of Aseptic-Thermo Indicator Co., North Hollywood, Calif.; and **Col. John D. Peterman,** commandant, Quartermaster Food and Container Institute for the Armed Forces, Chicago. The occasion was the first meeting of a new task group that will study critical storage temperatures of frozen foods. The task group, under the chairmanship of Mr. Beckett, was activated jointly by the R&D Associates and the Quartermaster Institute.

◆ ◆ ◆

Food Machinery and Chemical Corporation's Canning Machinery Division has announced the appointment of **J. E. Standiford** and **Michael W. Ward** as territory representatives on the Division's Eastern sales staff. Mr. Standiford, formerly vice president and general manager of Klondike Canners, Inc., Lafayette, Ind., has taken charge of the Indiana-Ohio-Kentucky territory, with headquarters located at East Union St., R. F. D. No. 4, Lafayette, Ind. Mr. Ward, formerly a plant manager with the Birds Eye Division of General Foods Corporation, has been assigned to the Illinois-Michigan territory with headquarters at the company's offices in Hoopeston, Ill.

◆ ◆ ◆

From A. E. Staley Mfg. Co., Decatur, Ill., corn and soybean processor, comes news of the following promotions: **Mr. Paul Breyfogle** to the post of technical assistant in industrial sales; **Mr. Byron Fast** to the position of sales service engineer; **Mr. Roscoe Long** to senior chemical engineer; **Mr. Robert E. Nisbet** to chemical engineer; and **Mr. Robert C. Hanna** to industrial sales representative in Dallas, Tex.

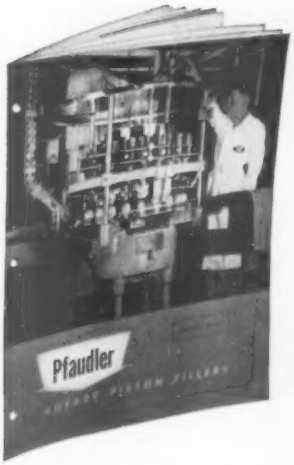
◆ ◆ ◆

The rapidly growing technical staff of Dodge & Olcott, Inc., 180 Varick St., New York City, has been further expanded by the addition of four new chemists. **Mr. William Ammon,** former supervisor of quality control for the Stange Chicago plant, has joined the staff of the new D&O Dry Soluble Seasonings Dept. **Mr. Jake Glueck,** with a background of 14 years in the flavor industry, has joined the D&O Flavor Department Laboratories. To the technical staff of the D&O Perfume Laboratories has been added the services of **Mr. Fritz Schubert** and **Mr. Ray P. Williams.** Mr. Schubert is an industry veteran of 30 years, and Mr. Williams has spent the past eight years as quality control technician for Du Pont.

◆ ◆ ◆

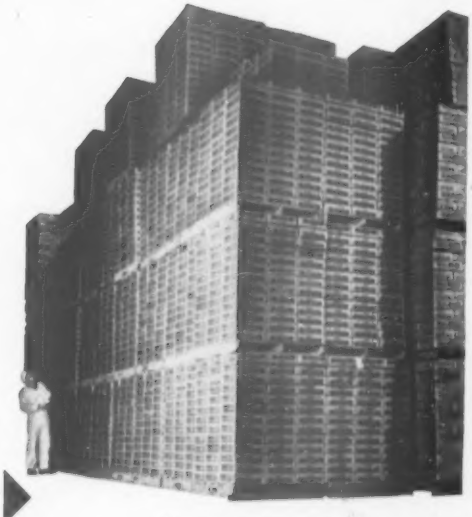
Mr. Charles R. McIntyre, Jr., has joined the Orkin Institute of Industrial Sanitation as a staff sanitation consultant. Lo-

(Continued on page 45)



This new booklet

. . . can show you how to do this



This tower of cases represents a typical eight-hour day's output—242,000 jars of baby food—on a Pfaudler RP-21 Piston Filler at Beech Nut Packing Co.

. . . and answer these questions:

Exactly how does a rotary piston filler operate?

- Diagrams and explanation show you how!

How can I lower the cost of cleaning food fillers?

- Booklet shows you how 1 man, using no tools, can do the job in less than ½ hour!

Can you guarantee the speed of filling my products?

- Typical chart gives examples of guaranteed filling speeds!

What fillers are available, and what jobs are they designed for?

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☐ I am working on a problem in filling.

☐ I want to bring my literature library up to date.

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QUALITY THAT SPEEDS SALES, by a filtration method that speeds production . . . this double advantage is yours with Celite* diatomite filtration.

You obtain brilliant polish, because Celite removes even the finest suspended impurities. Yet you secure the fastest flow rates consistent with desired quality, because a Celite filter cake contains millions of microscopic filter channels per sq. ft. of surface. For example, with a typical syrup, you can achieve excellent clarity at a flow rate of 10 gal/sq ft/hr—using a standard grade of Celite!

Production men also favor the Celite method because of its simplicity. It may be used with any type of conventional filter unit, and it is almost automatic in operation. For maintenance work too, Celite Filtration is the economical, efficient way to obtain pure process water for bottle washing, equipment cleaning and other service functions.

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*Celite is Johns-Manville's registered trade mark for its diatomaceous silica products.

JM PRODUCTS **Johns-Manville CELITE** FILTER AND PRESSING AIDS

FOOD INDUSTRY TOPICS

(Continued from page 42)

cated at 418-B Ross Ave., Dallas Tex., he will be responsible for sanitation consulting services to clients of the Orkin Institute in Texas and neighboring states. Mr. McIntyre, a graduate of Southern Methodist University, was formerly associated with the engineering section of the Dallas County Health Dept.

◆ ◆ ◆

Mr. George H. McGlynn, vice president and treasurer, Magnus, Mabee & Reynard, Inc., New York City, has recently returned from a six-week trip to Europe where he visited leading producers of essential oils and a number of the company's agents.

◆ ◆ ◆

At the Sixth Annual Meeting of the American Association of Candy Technologists, held in Chicago in June, **Mr. Justin J. Alikonis,** director of research, Paul F. Beich Co., Bloomington, Ill., and president of the AACT, was presented with the Stroud Jordan Award for his work in fundamental and practical research, his services to the Army Quartermaster Corps, the National Confectioners' Association, and the AACT, and his ability to stimulate the members of the candy industry to think along technological lines.

◆ ◆ ◆

Mr. Adolph Dingfelder of Felton Chemical Co., Brooklyn, N. Y., is currently on a six-month tour of duty in Europe, surveying business conditions and checking the world-wide Felton operation. He is making his headquarters at the Felton office and plant in Versailles, France.

◆ ◆ ◆

Mr. Clarence Francis, retired chairman of the Board of General Foods Corp., has been unanimously elected to receive the 1954 Henry Laurence Gantt Gold Medal. The Gantt Medal is considered to be the highest award made in the field of management. It is administered jointly by the American Society of Mechanical Engineers and the American Management Assn. Mr. Francis resides in Bronxville, N. Y.

◆ ◆ ◆

From Celanese Corporation of America, 180 Madison Ave., New York City, comes news of the appointment of **Mr. Jack T. D. Cornwell** as advertising and sales promotion manager of the firm's Chemical Division, and the transfer of **Mr. Verne Nazarek** to New York City as assistant to **Mr. M. S. Kirpalani,** export manager of the Chemical Division.

◆ ◆ ◆

Miss Janet Alice Ball has joined the staff of Hines-Park Foods, Inc., Ithaca, N. Y., as home economist, according to **Mr. Everett L. Ackley,** director of the company's quality control division. Miss Ball, formerly a food technician with General Foods, will be in charge of the Duncan Hines test kitchen in Ithaca. She will also assist Mr. Ackley as director of research and product development.

◆ ◆ ◆

Mr. A. E. Cleghorn has been named executive vice president, National Aniline Division, Allied Chemical & Dye Corp., New York City, according to an announcement by **Mr. D. G. Rogers,** Division president. Associated with Allied Chemical since 1933, Mr. Cleghorn has been with National Aniline Division since 1952, serving successively as assistant to the president and vice-president.

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Advertisers' Index

	Page
Abbott Laboratories	2nd cover
American Can Company	18 and 19
Aseptic Thermo Indicator Company	40
Continental Can Company	32 and 33
Diamond Crystal Salt Company	30
Distillation Products Industries	14 and 15
Dodge & Olcott, Inc.	27
Felton Chemical Company, Inc.	9
Firmenich, Inc.	3rd cover
Food Development Laboratory	46
Food Machinery & Chemical Corp.	17
Food Research Laboratories Inc.	46
Fritzsche Brothers, Inc.	7
Givaudan Flavors, Inc.	34
Griffith Laboratories Inc.	37
Hoffmann-La Roche Inc.	4
International Minerals & Chemical Corp.	29
Johns-Manville Corp.	44
Knickerbocker Mills Company	23
LaWall & Harrisson	46
Magnus, Mabee & Reynard, Inc.	26
Monsanto Chemical Company	25
National Aniline Division	21
Neumann-Buslee & Wolfe, Inc.	42
Norda Essential Oil & Chemical	4th cover
The Pfaudler Company	43
Chas. Pfizer & Company, Inc.	35
F. Ritter & Company	45
Rohm & Haas Company	5
Schwarz Laboratories, Inc.	46
Sheffield Chemical Company	39
A. E. Staley Mfg. Co.	41
Wm. J. Stange Company	1
Sterwin Chemicals Inc.	11
Takamine Laboratory, Inc.	31
Truesdail Laboratories Inc.	46
U. S. Steel	13
van Ameringen-Haebler, Inc.	3
Wisconsin Alumni Research Foundation	46

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AVAILABLE: Food Technologist with diversified experience in food and dairy product manufacture, development, and control. Business management background. Desires connection in technical sales or service. Midwest location preferred. REPLY BOX 344, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

CHEMISTS: Manufacturers of citrus concentrates and allied flavoring products have excellent opportunity for technologist to take charge of production control laboratory. Plant is located in Southern California. Experience desirable. Must be able to supervise other employees.

Same company has opening for Food Technologist willing to travel as technical supervisor to associated plants.

Give full details regarding experience, personal background, salary requirements and references. Enclose recent photograph. REPLY BOX 346, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

TECHNICAL DIRECTOR

National food processor with eastern headquarters seeking highly qualified man to assume direction of Research, Quality Control, and Process Development effort. Must be strong leader able to assume heavy administrative and coordinating responsibility. Prefer man between 30 and 40 with advanced degree in scientific area. Salary commensurate with qualifications. Send complete resumé background, experience and training to BOX 348, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

WANTED: Chemist for Quality Control by large manufacturer of non-carbonated, canned, juice-type beverages, nationally distributed. Good opportunity. Location Florida. REPLY BOX 347, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

WANTED: FOOD TECHNOLOGIST—to organize and conduct taste panel program and assist in quality control work for Midwestern supplier of adjuncts to food manufacturing industry. Our employees have been informed of this advertisement. REPLY BOX 349, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

PRODUCTION & RESEARCH CHEMIST, with extensive and diversified experience in production, supervision, development, chocolate, and numerous other food products, desires position to fully use his ability. REPLY BOX 350, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

WANTED: Food Technologist. For research and development work by food processor in Chicago. Good opportunity for advancement in rapidly expanding, well-established concern. Require B.S. degree, preferably under 30. Send resumé to BOX 343, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

AVAILABLE: Biochemical Engineer. B.S., Ch.E., M.S., Biochemistry, Food Technology. Responsible process development, plant design, container, and food plant waste experience. Interested in medium to medium small organization. REPLY BOX 351, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

QUALITY CONTROL SUPERVISOR WANTED

Man qualified by technical training, and preferably one with a few years experience, to organize, and head up a Quality Control Department, for a Meat Packing Company located in the east. Give full details regarding experience, and age. BOX 345, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

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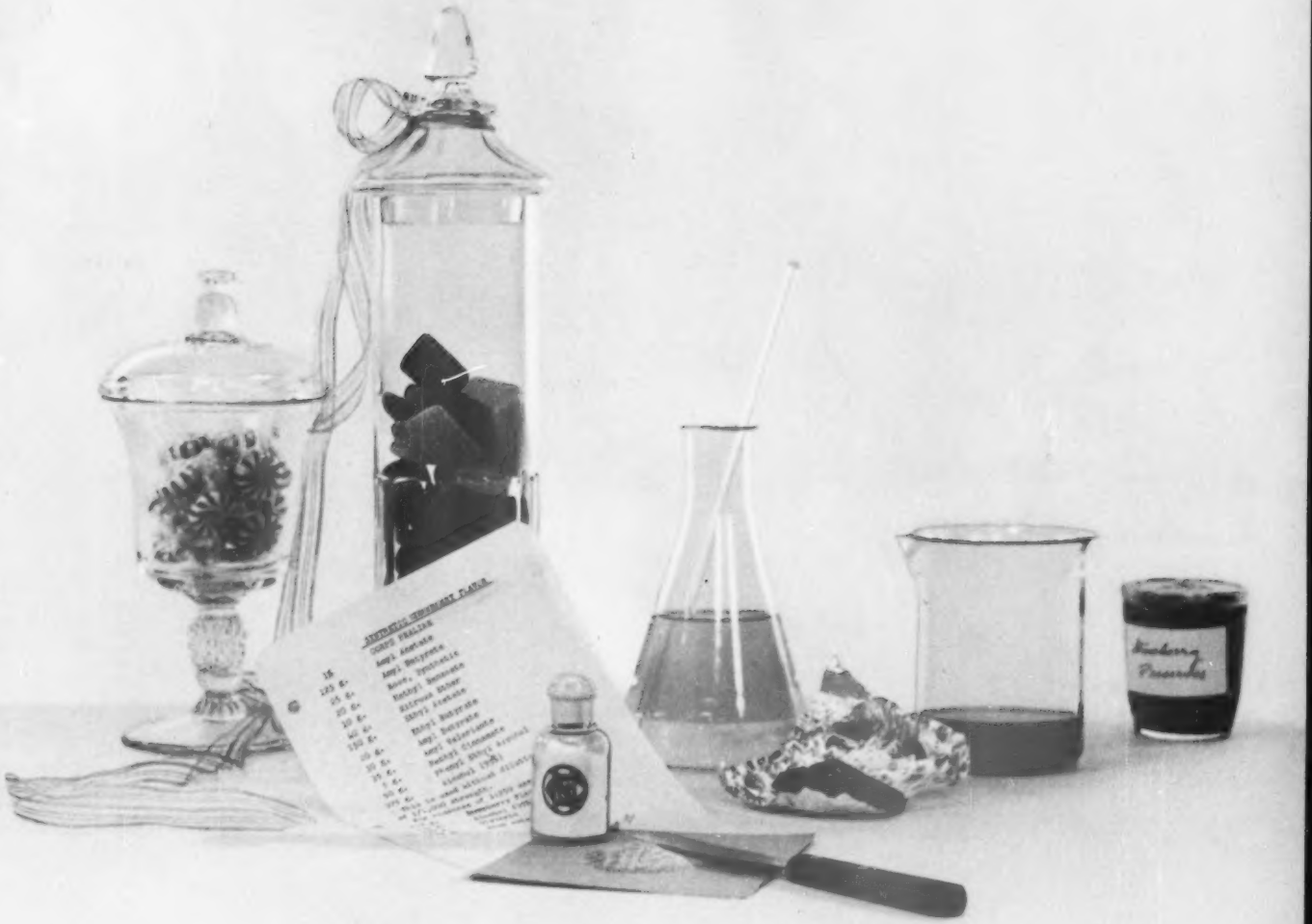

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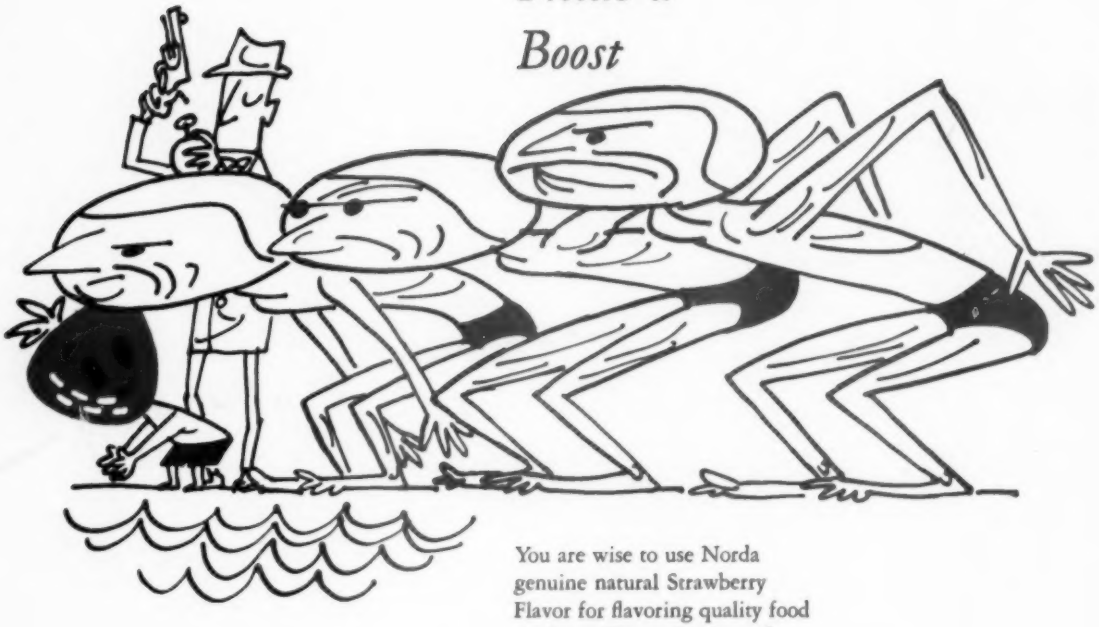

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